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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · AUGUST 28, 1961

facts about

RANGER I

- *parameters*
- *control*
- *command*

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MAGNETIC CLUTCHES FOR CONTINUOUS SLIP . . . p 23
HOW TO SELECT DRAFTING PAPER . . . p 31

When selecting roller-bearing pillow blocks, remember

it's what's inside that counts!

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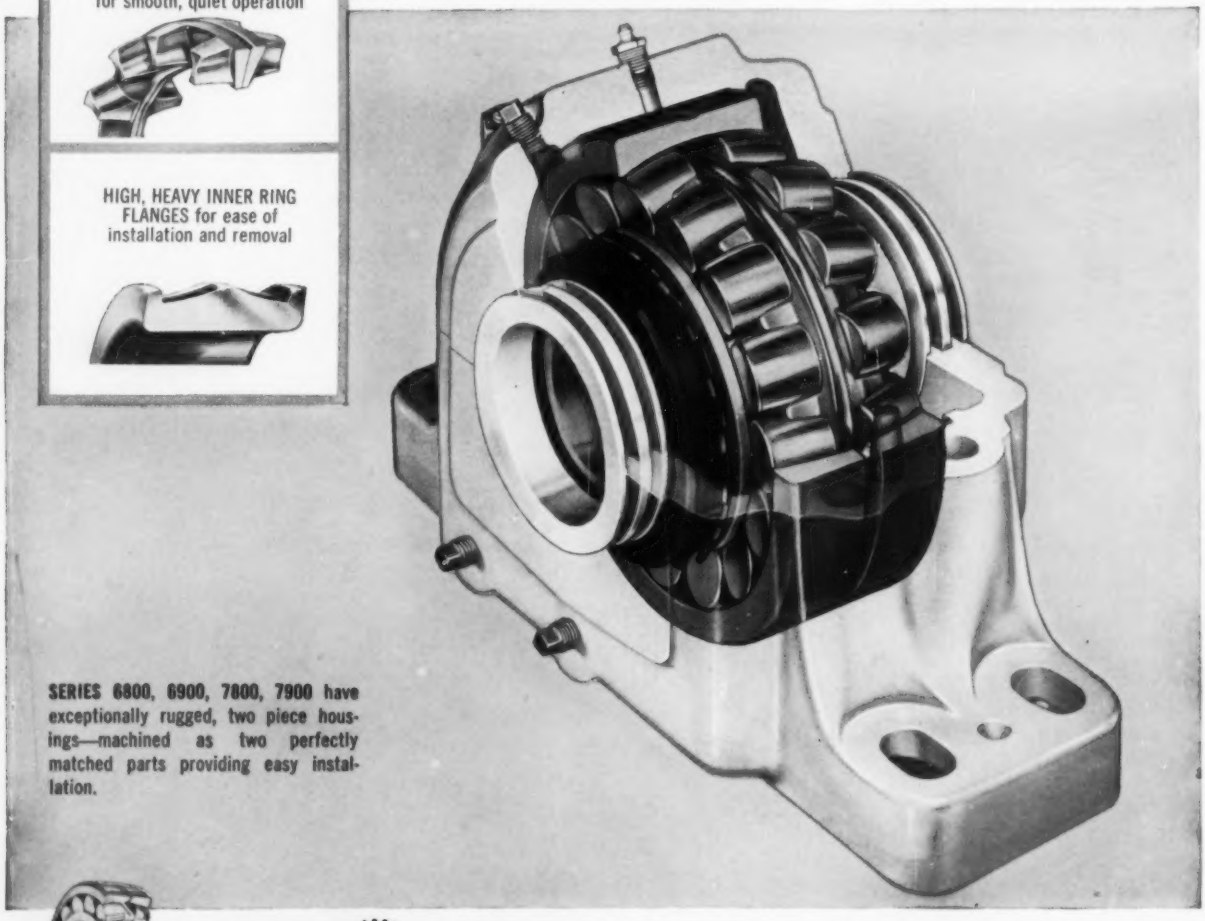

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

AUGUST 28, 1961

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THE COVER . . .
Ready for launch, with the umbilical gantry still supplying ground power, is US's latest major space experiment. The Atlas-Agena B rocket combination will start the Ranger 1 spacecraft on a 50-day trip into space (half-million miles out and back). Convair's Atlas will boost the spacecraft some 80 miles high. The sophisticated Lockheed Agena B will then place it into a near-circular earth orbit and then blast the JPL-designed Ranger into space. Later Ranger spacecraft will put highly sensitive instruments on the lunar surface.

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INTERESTING TO NOTE

the great paper robbery

If Red China is able to worm any valuable secrets from their Soviet allies, they will, in a sense, be in return for Russia's great theft in the year 751. At that time the two nations were at war. China was a vast economic and cultural center while Russia was considered to be inhabited by barbarians. During the conflict, however, Russian warriors were able to force their Chinese prisoners of war to reveal the 600-year-old secret process of making paper.

Part of a French 18th century paper factory. In order to take ink without running, the paper had to be sized with a gelatinous animal glue. The sizing, obtained from hides, was processed and used in this room. After sizing, the paper had to be dried, each sheet hung from horizontal wooden beams like wash on a clothesline.

Prior to around 150 AD there were several crude forms of "paper." Egyptians wrote on thin strips of papyrus, a native plant; Babylonians used heavy clay tablets; Persians made parchment by splitting the skin of goats, sheep and calves, soaking them in lime, scraping them smooth then drying them. In early China, silk was the most common writing material—until the scholar Ts'aihn discovered a better way to make paper. He pounded mulberry bark into pulp, added water, then dried the mixture into flat fiber sheets on which messages could be written. It was the first real paper, and the Chinese kept their process secret until it fell into Russian hands 600 years later. It took another four centuries before the paper-making formula reached Europe, but by that time rags were being used for pulp instead of mulberry bark.

During the American Revolution, officers of Washington's continental army wrote on paper fragments that looked more like grocery lists than official documents. After Washington's election, the shortage became so serious that Congress appealed to housewives to save rags for paper manufacturers.

In the 18th century French scientist Rene de Reaumur noticed that wasps rubbed tiny wood fibers loose from a dry post and mixed them with secretions. In drying, it formed a thin, paper-like material from which the wasp built its nest. In 1844, a German, Frederic Kellar patented the first practical method of imitating the wasp's work—a wood grinding machine in which sticks of wood were forced against a grindstone and water added. The pulp was then made into paper.

The paper industry has grown so rapidly that the US per capita consumption has jumped from 25 lbs in 1930 to 438 lbs in 1959, but not all of this needs the high quality and strength of drafting paper. Woven cloth and even plastic films are now used—see page 31.

the pope and the abacus

Adding a series of numbers can be accomplished by paper and pencil or a variety of machines ranging in price from pennies to thousands of dollars. Calculating by machine goes back to the familiar abacus. In fact the word "calculate" is derived from the markers or *calculi* on the wires of the abacus. Around 950 AD, Gerbert, later to become Pope Sylvester II, introduced the abacus to the European community. Supposedly, he learned of it through the Arabs while in Spain. Sylvester had a thirst for science and mathematics and undoubtedly was intrigued when he first saw the device for adding and subtracting. Unfortunately Sylvester's interest in science gave him the false reputation of magician or wizard.

In 1642 nineteen-year-old mathematician Blaise Pascal, built the first simple digital calculating machine for his father, a customs officer in Rouen. It was nearly two hundred years later before Charles Babbage designed his famous calculating machine. With the advent of Babbage and the mechanical computer, the abacus was more or less forgotten. In 1946 however, the American army staged a competition between a Japanese clerk, Kihoshi Masturaki and an American Private Wood. Masturaki used his abacus while Wood used an ordinary desk calculator—the abacus beat the calculator every time.—**Benedict A Leerburger, Jr.**

Ranger 1 experiments pave way to space travel

- **Latest and most complicated step in NASA's program to explore the moon, planets and interplanetary space.**
- **Forerunner of later models in the same series that will rough-land instrumented packages on the moon.**

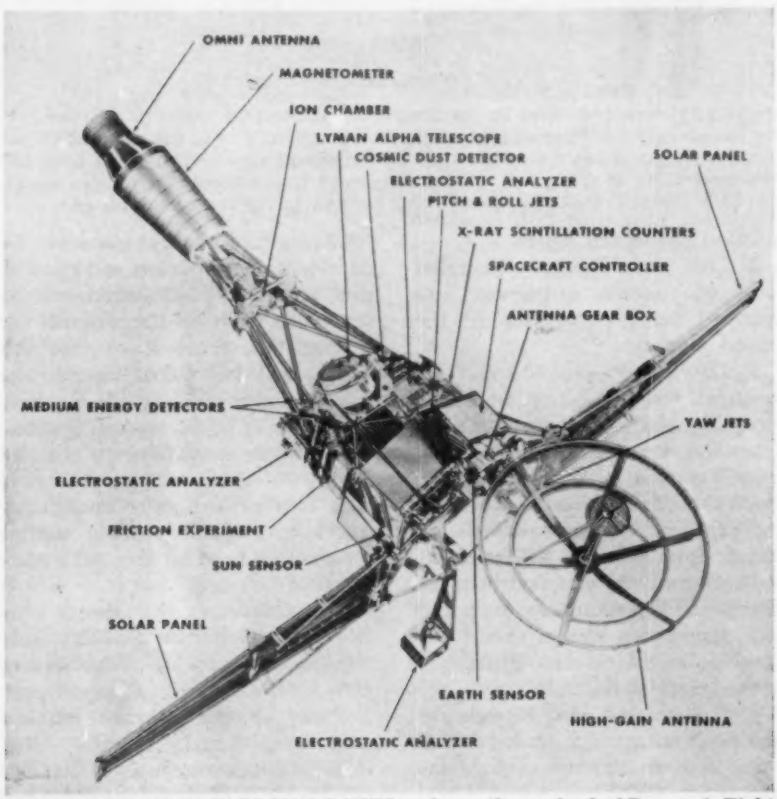
NEW YORK—Phase 1 of manned space travel is Ranger, which eventually will rough-land instrumented packages on the moon. The first Ranger shot, however, is to develop and test basic elements of spacecraft technology required for lunar and interplanetary missions. These include an attitude stabilization system based on celestial references, a high-gain pointable antenna, an advanced communication system, the development of components able to operate for long periods in space environment, and calibration of solar cells in a space environment.

In view of the developmental nature of the spacecraft, Ranger 1 will not be aimed at the moon, but will be sent off on a long trajectory into space, reaching more than 500,000 miles out before returning to burn up in the earth's atmosphere after more than 50 days in space.

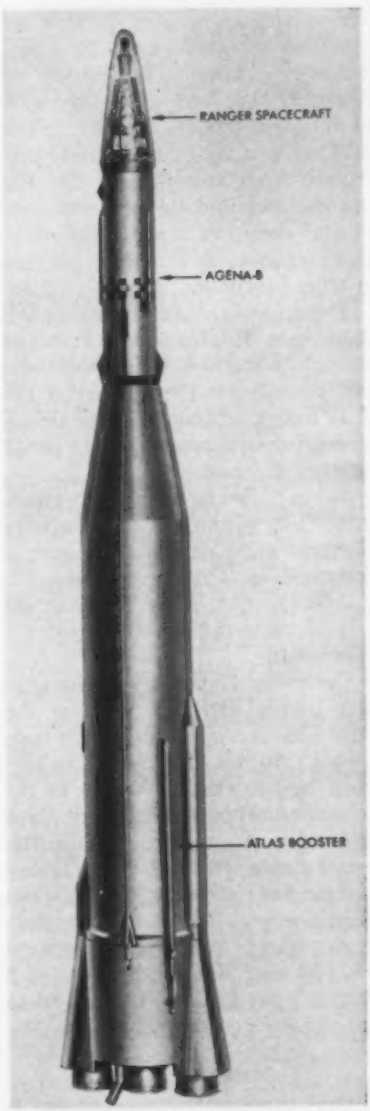
SPACECRAFT PARAMETERS

Ranger 1 is about 5 ft dia at the base of the hexagon-shaped configuration and 11 ft long. In its cruise position, with the solar panels extended, it has a 17-ft span and is 13-ft long. It weighs 675 lb—243 lb of electronics, 144 lb of scientific instruments, 50 lb of solar panels, and 238 lb of structure.

Rising from the hexagonal base are four struts and four diagonal braces of aluminum which support the scientific instruments. Two solar panels, each about 10 sq ft, carry 4340 solar cells—a total of 8680. They are expected to pick up enough solar energy to be converted into a minimum of 155 watts and a maximum of 210 watts. Ranger power demand peaks at 150 watts. The two solar panels



19,250 WORKING ELECTRONIC PARTS make up the payload of Ranger 1. Eight scientific experiments will be performed and the information used to guide future manned flights to the moon and beyond.



LAUNCH VEHICLE SYSTEM consists of a Convair Atlas first stage, a Lockheed Agena B second stage, and the Ranger spacecraft. Atlas places vehicle about 80 miles high and separates. Agena carries the spacecraft to 100 miles and places it in a near-circular orbit. A second firing of the Agena rockets puts the spacecraft into its planned 50-day orbit.

are hinged on a framework below the hexagon, and in launch position are folded.

In the hollowed-out inner section of the hexagon is a silver-zinc battery with a capacity of 9000 w-hr. This is a backup power source and supplies the power to run the spacecraft up to the moment when the solar panels are activated. The battery could run the spacecraft for two days.

SPACECRAFT CONTROLLER

Six electronic boxes located on either side of the hexagonal base contain the electronic intelligence of Ranger 1. One is the controller which permits the craft to calculate when it should perform what function, how it should roll and pitch to find the sun and lock into this position, how to find the earth and aim its directional antenna at the earth, as well as other functions.

The controller is an electronic solid-state timer. It takes 400 cps from the power source, divides it into one pulse per sec and uses these pulses as the basic timing reference. Pulses are accumulated in a memory with a preset series of triggers.

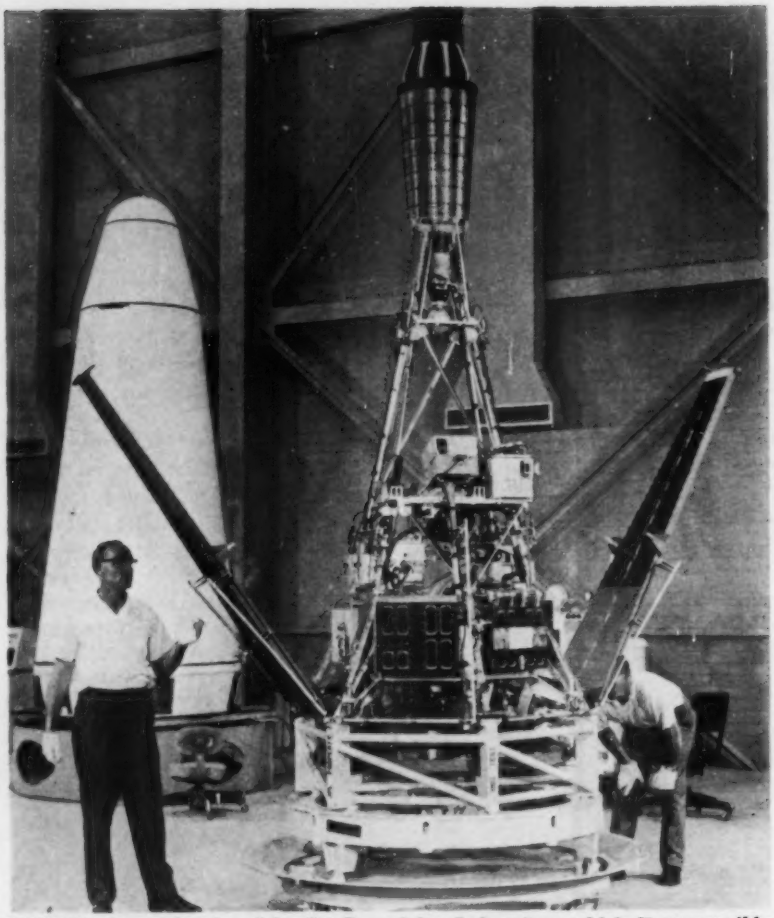
When the accumulated pulses match that of the first trigger a relay is closed and the controller issues a command to the craft to perform a specific function. From launch to the end of its useful life there are ten commands.

Controller is started 3 minutes before launch, and this serves as the zero reference point for future commands. At this time power is supplied by the internal battery to the scientific instruments and both a ¼-w and a 3-w transmitter. Some instruments are not activated during launch and the 3-w transmitter is initially run at half power. This is done because, as the launch vehicle passes between 150,000 and 200,000 ft, there is a tendency for high voltage devices to arc and damage themselves.

COMMAND SYSTEM

Once Ranger 1 is pointed on its trajectory, the command system starts its 10 discrete steps. These are:

1. 1500 sec (25 min). First command increases power to the large transmitter stepping its power from 1.5 to 3 watts. Increased power permits the ground station (one of three) near Johannesburg, South Africa to monitor telemetered signals.



RANGER 1 was developed by Jet Propulsion Laboratory which is responsible for the execution of current projects in the unmanned part of the program. The hexagonal-shaped basic configuration will be essentially unchanged in form in this generation of spacecraft. At left, is shroud that protects instrument package from damage caused by aerodynamic heating during the launch phase.

2. 2100 sec (35 min). Controller turns on scientific instruments not operating during passage through the critical altitudes.

3. 2200 sec (36 min, 40 sec). Two functions: First, extend by compressed spring the electrostatic analyzer package. This a small box on a boom about 4 ft from the main body of the spacecraft. Two sensors can look at and away from the sun without interference from the body of the spacecraft. Second, the pins that hold the solar panels locked in place are pulled and compression springs unfold the panels until they are at right angles to the length of the craft.

4. 3700 sec (61 min, 40 sec). Attitude-control system is turned on and power sent to the sun sensors, the cold-gas jets and the gyroscopes. Gyros first act to cancel residual movements that result from separation.

12 sun sensors—light sensitive diodes—inform the gas jets and gyros of sun position. The attitude-control system responds to these signals by turning the spacecraft so that the longitudinal axis points towards the sun. Torquing of the vehicle for these maneuvers is by 10 cold-gas jets fed from a bottle about 8 in. dia containing 2½ lb of nitrogen at 3000 psi. This is calculated to be enough nitrogen to maintain attitude control for a minimum of 50 days and a maximum of 100 days.

To conserve gas, the attitude control system permits a pointing error towards the sun of 1°. The mixing network is calibrated to keep Ranger 1 slowly swinging through this arc once every 60 min. As the ½° limit is reached, the sensors signal and the jets fire for $\frac{1}{10}$ of a sec. Once the sun is spotted and held within the allowable limits the battery is turned off

and power comes from the solar cells.

5. 5600 sec (93 min, 20 sec). Directional antenna, which moved into position on above signal, starts searching for the earth, but without losing the sun position. Three earth sensors, photomultiplier tubes mounted co-axially with the directional antenna, roll the spacecraft about its long axis with the directional antenna extended at a predetermined angle. Once the earth is located, the gas jets are activated and lock the craft onto the earth. The spacecraft is now stabilized on two axes, the solar panel-sun axis, and the earth-directional antenna axis.

6. 7100 sec (118 min, 20 sec). Scale factor of telemetry which informed earth of Ranger wobbling after separation from Agena B is adjusted to a lower rate now that the sun sensors have the system under control.

7. 12,000 sec (200 min). Scale factor of one of the radiation instruments is changed. Of the six units, one is made more sensitive to give a finer measurement of the radiation level.

8. 15,000 sec (250 min). Data being transmitted from the three watt transmitter are transferred from the omnidirectional antenna to the directional antenna, thereby increasing the range from which the information can be sent. The ¼-w transmitter continues to send the same data over the omnidirectional antenna.

9. 22,000 sec (366 min, 40 sec). Rate of data being sent by the smaller transmitter is reduced. The low-power transmitter is near its limit because of distance, so by reducing the amount of information, its ability to communicate over longer distance is improved.

10. 22,200 sec (370 min). An engineering experiment is started to determine some of the friction forces involved in the operation of machinery in the hard vacuum of space. It is known that most metals moving against other metals in hard vacuum have a tendency to stick together. This experiment, designed to determine the effect of space environment on bearing materials. It consists of a motor-driven shaft on which are mounted a series of disks of different materials. Pressing against the disks are hemispheres of different material. There are 80 material combinations being tested. Strain gages mounted on each hemisphere telemeter the drag force between combinations. ■

Explosion creates artificial diamonds

MENLO PARK, CALIF—Diamonds have been produced at the Poulter Labs of Stanford Research Institute during a program to test the effects of explosive shocks on various materials. The experiments by Paul S. De Carli of SRI and James C. Jamieson of the Univ of Chicago produced minute particles of diamonds from fragments of pure graphite when subjected to shock of 30,000 atm for one microsec. The graphite was artificially produced to assure spectrographic purity.

De Carli believes that the diamond formation depends on the structure of the graphite. Graphite is composed of sheets of atoms arranged in either of two characteristic patterns. The less common of these forms is similar in structure to diamond, except that in diamond the sheets are puckered and much closer together. The explosive force puckers and compresses the graphite to form diamond.

After experiments with both hexagonal and rhombohedral graphite, the latter was selected as approaching the pattern of diamond. Further experiments showed the compression shock wave were only effective when applied along the c-axis of the graphite crystalline formation.

The experiment was performed by placing an explosive charge atop an unrestrained graphite specimen over a container of water. Following the explosion small diamonds were recovered from the water.

DIAMOND PARTICLES resulting from explosive shock are real, though very small. The average was 10 microns in dia; the largest, 40 microns. They were identified by their X-ray and electron diffraction patterns and by hardness tests at the Univ of Chicago.

Current methods of diamond synthesis requires a high investment in capital equipment and the capacity of the equipment is limited by the strength of available engineering materials. Here, the capacity of the explosive method is limited only by the amount of noise and this can be muffled. However, commercial value of the process is not apparent at this time.

—William B. Wallace, Regional Editor

India strives for technical independence

NEW DELHI—India is trying to cut down her dependence on foreign technical experts. The state-owned National Industrial Development Corp recently set up a nucleus Technological Consultant Bureau, staffed by specialists in process and product designs, engineering and construction. The Bureau will prepare project reports, inspect sites and supervise and inspect construction of industrial projects proposed for the public sector of India's economy. Later its services will be available to private industries as well.

For the past several years, India has been wholly dependent on foreign technical advice. Experts were invited from abroad to prepare project reports on various industries to be set up here. Their services are expensive and add considerably to foreign exchange cost of projects.

In almost all such cases, basic details are given to the foreign experts by the Indian government such as: quantitative demand for the finished product, availability of raw materials, local salaries and construction costs. The reports of foreign teams have been valuable, but the government has concluded there is no need for seeking expert advice for preliminary foreign project reports.

The new Bureau will not obviate the need for foreign expert advice in

engineering news continued on page 6

preparation of detailed project reports of major new industrial undertakings, but it is expected to encourage development of engineering know-how and experience in this country. Also, it will eliminate the necessity for accepting a package deal with foreign contractors. These deals, including project report, design and construction of a plant, are inescapable as long as India lacks technical know-how.

Package deals have certain disadvantages. They take away the client's right to select the most suitable equipment or the best contractor for each part of the project. Often, too, consulting firms are compelled by their own affiliations to supply equipment from sources that might not be best for a particular job. Past experience has also shown that foreign consultants lack knowledge of Indian conditions and make excessive provision for contingencies.

The Bureau has five major divisions:

- **A process and product design section** to design new products for industry, to recommend suitable processes based on latest technical developments and to help test and analyze materials and end products.
- **A project engineering section** to make preliminary analyses of technical and economic feasibility of proposed projects after process is selected.
- **An engineering design section** to do plant layout and make working drawings for construction.
- **Inspection section** to inspect and certify equipment from suppliers.
- **An erection supervision section** to supervise construction and initial operation of the plant. Its experts may also be available for factory training.

The Bureau is expected to turn out preliminary reports for four projects each year and detailed reports for at least two medium-size projects, costing about $10 million each. Operating budget will run about $160,000 a year.

—Sharokh Sabavala, Bombay bureau

Underwater telemetry to probe ocean depths

San Francisco—Development of an underwater telemetry system has been announced at the WESCON show here by Bendix-Pacific of North Hollywood, Calif. Company spokesmen say the system has been fully tested and is ready for installation in appropriate applications although no such installations are presently scheduled. These include:

- **Geophysical exploration** for undersea oil fields can be done by telemetering significant information from bottom crawlers or weighted probes.
- **Biomedical research,** similar to that for astronauts, can be made with instrumented divers.
- **Oceanographic studies** of temperatures, currents, chemical concentrations at varying depths.
- **Submarine DEW line** could be quickly set up using the underwater telemetry system in conjunction with properly spaced sonobuoys. Line could detect submarines passing over it.

Basically, the system accepts standard telemetry signals at an underwater source, amplifies and converts the electronic signals into sonic waves which are transmitted to a hydrophone. When received by the hydrophone the sonic signals are reconverted to electrical form for data reduction.

The source-signal transducer, called the sonar projector, can be as small as 3 x 4 x 1½ in. and weigh as little as 1 lb. Using a power supply consistent with the concept of small size, the sonar projector has a range of five miles. Distance between signal source and data receiving station can be extended beyond five miles by using sonobuoys as relay stations.

The sonar projector accepts and converts 10 continuous subchannels of information from instrumented probes. The first step of conversion is to frequency modulate each of the subchannels onto a main electronic carrier. The second step converts the electronic carrier into a sonic signal for transmission to the hydrophone. If the hydrophone is located on a sonobuoy, the sonic signal is converted into a single electronic carrier and transmitted via radio to the data reception station. If it is located at the data reception station, the sonic carrier is converted into a single electronic carrier and separated into subchannels.

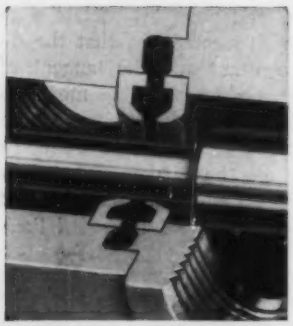
Bendix-Pacific believes that present on-board recorders in underwater vehicles can be replaced by sonic projectors. Important savings in space and weight will be realized as well as acquiring all data through telemetry in case the vehicle is unrecoverable or lost. Also, remote control of underwater vehicles will be possible without the limitations of a heavy umbilical cable now used on several research vehicles. The underwater telemetry system is simply reversed and the sonic projector becomes a signal receiver.

—William B. Wallace, Regional Editor

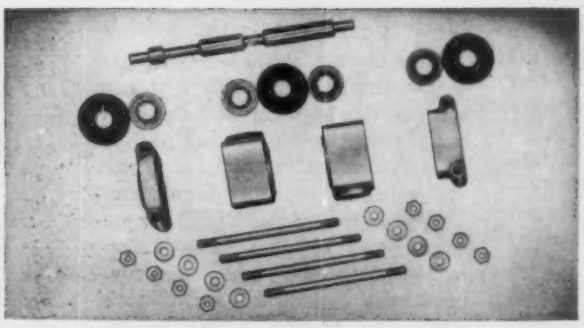
Sprayed-on, high-temperature strain gages

Heat sensors, erosion and ablative gages, and other high-temperature measurement devices are being flame sprayed on metal surfaces at Boeing. A spokesman for the company's Aero-Space Div, says that the sprayed-on sensors have withstood temperatures to 1200 F and expects the limit to be pushed past 2000 F. The surface is first sprayed with an insulating layer of aluminum oxide (a better insulator is being developed as aluminum oxide fails in adverse environments). A nickel-chromium alloy is then sprayed through a stencil to act as the sensor.

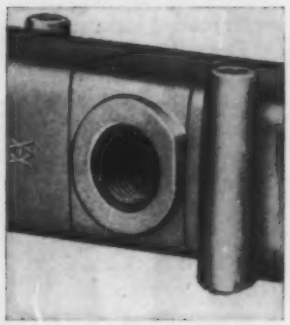
Do the air valves you buy include these quality features?



SEAL—Exclusive, triple-supported seals permit interference fit of spool for extra-tight closure with minimum wear. Usual damage to conventional "O" rings by moving spool is eliminated.



SIMPLICITY—Uncomplicated parts mean long life and easy servicing. Common parts are used extensively to simplify stocking or repair.



FLEXIBILITY—Modular Construction. Operators, mounting holes and ports may be independently rotated in 90° steps. Operator may be on either or both ends.

This high-quality "D" Pilotair® Valve is available in thousands of combinations. Tailored valves at standard model prices. Nine basic valves may have one or two of eight operators. Many types of spring return or holding functions.

if not, the chances are your maintenance costs are higher than necessary. For more information about quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A4-75.01.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

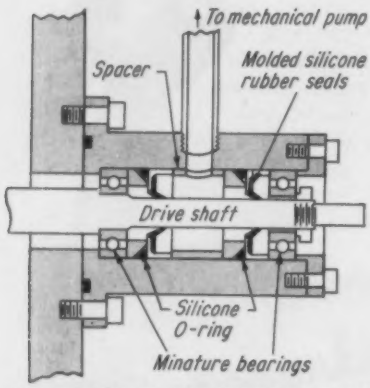
Divided seal solves vacuum problem

By dividing a rotary shaft seal into 3 sections, R. W. Roberts devised a system at Brown U's Metcalf Research Lab that is not only simple and inexpensive but also surprisingly effective in preventing leakage.

The system was designed for a shaft that is driven at speeds to 4200 rpm through the wall of a high-vacuum chamber.

Since the sealing area is divided into 3 sections, differential pumping is possible. The center one can be exhausted by a mechanical pump, thus greatly reducing the wear on the seal nearest the high vacuum chamber and making it possible to attain a lower base pressure in the main vacuum chamber.

Describing the unit in *Review of Scientific Instruments*, Roberts says it maintains a pressure of 1×10^{-7} torr (760 torr = 1 atmos) at zero rpm, and 7×10^{-7} torr at a shaft speed of 1000 rpm.



MOLDED SILICONE RUBBER SEALS divide sealing area into 3 sections to simplify exhaust problems. Shaft is also highly polished to reduce seal wear.

New data on bearings for cryogenic service

New tests of bearings running under loads at speeds to 9200 rpm in liquid nitrogen and in hydrogen gas confirm previous indications that nonmetallic low-friction separator materials are superior to metallic materials for cryogenic service, NBS engineers report. Best performance was obtained with silicate-filled TFE (fluorocarbon) resins. But other nonmetallics tested at NBS Cryogenic Engineering Laboratory (TFE-impregnated glass fiber and a modified TCFE) also outperformed such metallic compositions as silver-plated silicon iron bronze. The tests were made on 10 mm-bore bearings, operating under loads of 20 to 200 lb at −420 to −100 F.

New polymers from Britain

New organic semiconductors, and organometallic compounds that may serve as the basis for new thermally stable polymers are reported by Britain's National Chemical Laboratory. Paralleling, but not duplicating, similar work in the US and USSR, the program has already resulted in development of patentable organoboron compounds "of considerable scientific and commercial interest." They are unusually inert, yet highly volatile. One, for instance, melts at about 480 F, yet will sublime at temperatures as low as 300 F in a vacuum.

Also under development: new, and highly reactive oxidants, ion-exchange membranes, and a series of compounds that may find applications in high-energy fuels, fuel cells, and structural plastics.

More work needed on this new metal

The hope of finding a low-cost continuous, or even semi-continuous, process for production of pure zirconium has been dampened a bit by recent reports from the Bureau of Mines Albany lab.

Using a semi-continuous reactor process, billets have been produced containing as much as 83 % zirconium metal. However, intermittent operation resulted in high oxygen levels and consequent metal hardness (Rockwell A 64); and continuous operation of the reactor was difficult because of weld failure, corrosion, and recurrent plugging of the lines by salt and reaction products.

J. E. Mauser of Albany believes the semi-continuous reactor method, using sodium or magnesium to reduce zirconium tetrachloride, is a feasible one. But, better materials will be needed for reactor construction, new heating methods, and better methods for handling the liquid salt will have to be developed to overcome the present high maintenance costs.

Briefing the Soviet record

Studies of dielectric properties at superhigh frequencies (10^{10} to 10^{12} cps) were reported by G. P. Mikhaylov and A. M. Lobanov at the Second All-Union Conference on the Physics of Dielectrics. Tests of nylon, acrylic, polyester, and polyvinyl acetate plastics showed, surprisingly, that the dielectric constant and the tangent of the dielectric-loss angle are more dependent on temperature change than on frequency in this range. A report appeared in the conference transactions and is briefed in the *Current Review of the Soviet Technical Press* (60-21441-30).

Teflon-bronze bearings can safely be used at almost twice the specific load of conventional babbited components, Soviet researchers report. Tests of sliding thrust and journal bearings, as reported in *Vestnik mashinostroyeniya*, show a coefficient of friction of 0.11 to 0.085 at specific loads in the 14 to 76-kg/cm² range. The bearings are made by sintering tin bronze powder on a steel base and then impregnating with Teflon. The results confirm and reinforce other recent reports on these materials (*PE* —Apr 17, p 6).

As cathodes in high-powered electronic devices, Soviet engineers are testing lanthanum hexaboride. This rare earth compound, they say, acts as a typical metallic conductor, with a thermal coefficient of resistivity on the order of 0.060 microhm-cm/°C. Its thermal emf is independent of porosity at least over the 2 to 37% range—at temperatures to 3600 F. A report is contained in a USSR journal of physical metallurgy; but only a brief abstract is available in English.

New antifriction material with excellent wear resistance, good adhesion to metals, and other properties comparable to those of nylon, is claimed by Soviet engineers. The material is a polysulfide rubber-epoxy composition which, they say, is readily moldable and does not require additional heat-curing to develop full hardness.

Exact composition is not available, but a report by O. L. Petrov and A. D. Kurmayer on properties and applications appears in *Plasticheskiye massy* (1/61, p 46). —ARG

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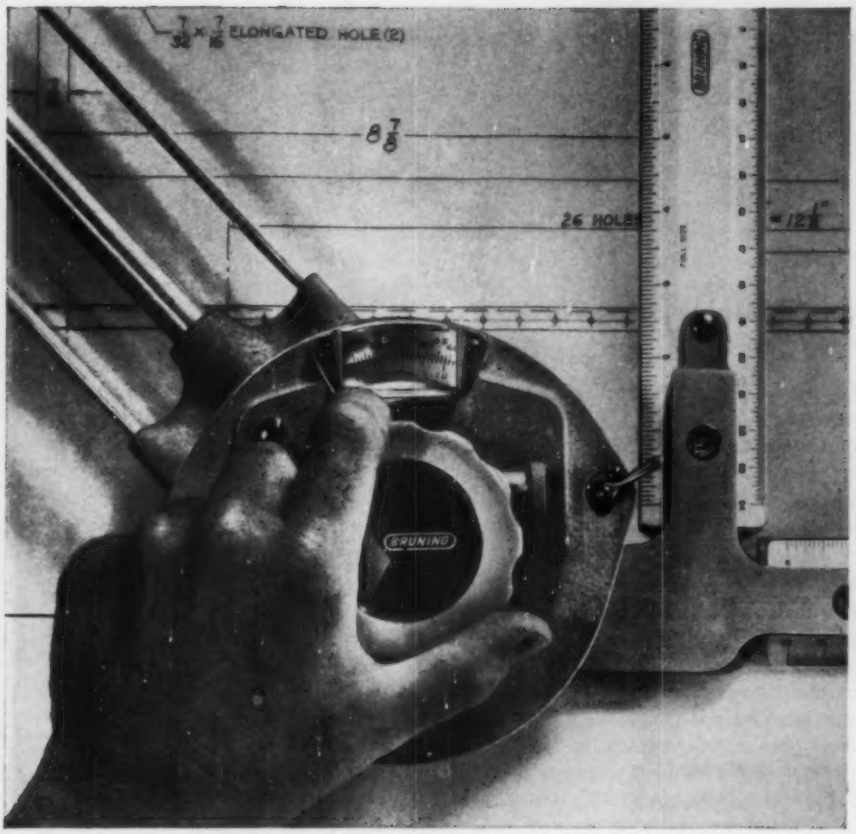

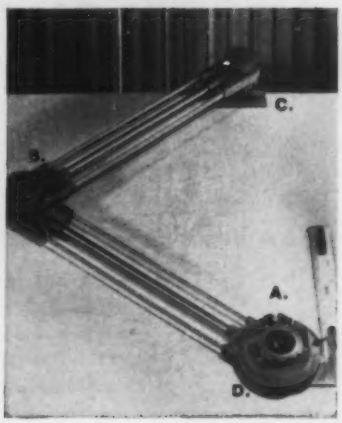

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DEVELOPMENTS TO WATCH

Semi-inorganic adhesives stand 975 F

New curing agents are making it possible to extend the range of polymer adhesives to 975 F, and there is hope the range can be extended still further. Furthermore, says H. H. Levine of Narmco R & D Div, Telecomputing Corp, high-temperature tensile shear is substantially improved.

These are complex systems—an epoxy novolak, a silicone-phenolic condensation polymer, and aluminum, with arsenic pentoxide as the curing agent.

In a report prepared for next week's American Chemical Society Div of Organic Coatings and Plastics Chemistry, Levine notes that arsenic pentoxide is not the only curing agent that can be used. Several other compounds may prove helpful; among them, vanadium pentoxide, barium oxide, and magnesium oxide.

Further research, he says, might provide methods for introducing other inorganic atoms into the polymer molecule—with still greater improvement.

Air Force shifts machine-tool goals

The emphasis will be on more versatile machines, suitable for small-lot runs, in the Air Force machine-tool program for the next several years.

J. S. Imirie, Assistant Secretary of the Air Force told the Machine Tool Builders Assn we have too many high-production machines and too many special-purpose machines that require excessive tooling. And, he says "the tools we do have are uneconomical for small-lot production. We actually need few machines designed for high production; instead, we want to concentrate on those that have multi-use capabilities."

Modernization will continue at the 2 to 5% rate; but, he says we are not doing so on a one-for-one ratio. Rather, by using the more versatile machines we are changing at a one-to-four ratio, buying one high-performance machine to replace as many as four older machines.

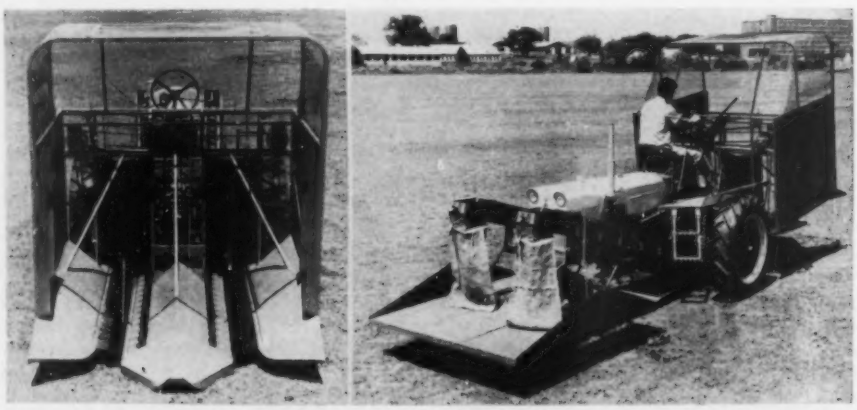
About 5000 numerically controlled machines will be procured, and special emphasis will be placed on 4- or 5-axis machines that can perform extensive metal-removal operations on structural parts; as well, of course, as those which can handle such "new" materials as vanadium, rhodium, molybdenum, and beryllium.

USDA tests new-type harvester

A harvester for castor beans is under test at Oklahoma Agricultural Experiment Station, and USDA says it's not only faster than hand-picking (the only method available until now), but also results in less damage to the beans.

The plants pass between brushes (see photographs) and a beater underneath the unit removes the beans. Then, an auger conveys them back to the sacking device.

USDA says the machine will harvest a plot 2 rows wide and 20 ft long in about a minute and a half. Manual harvesting would take at least 45 min.



NEW HARVESTER mounts on rear of small tractor (above) whose controls are reversed so driver can observe operation. The unit has two sets of brushes (shown in photo at left) to handle two rows of beans at a time.

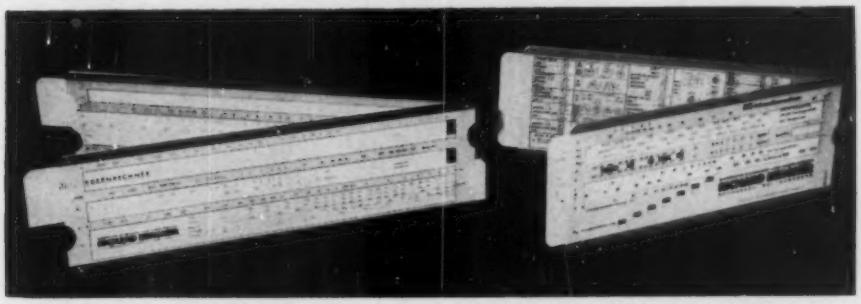
Slide rules coming for springs and screws

From Schwabach, West Germany (near Nurnberg) come two new slide rules to save time and money as well.

One, for springs, is claimed not only to be one of the easiest to handle, but also "by far the cheapest," of its kind. It's said to provide all necessary design data for compression, tension, and torsion springs (wire range from 0.1 to 10 mm dia), and has scales for load (in kg), mean dia of turns, shear stress for static and dynamic loads.

The rule for fasteners is designed for calculating bolt and screw sizes on the basis of several variables—dia., tensile strength, percentage of yield strength to be left as a safety margin, and so on. Diameter range is 2 to 20 mm.

Both are available for export sale. But, as yet, only with German markings and instruction manuals. The spring rule is priced at $2.15; the screw-and-bolt calculator at $1.40 (plus postage). Richard Bergner (RIBE) of Schwabach makes them.



SPRING CALCULATOR (left) and fastener rule (right) are made of sturdy plastic. Back of fastener rule gives head and shaft dimensions and other factors corresponding to settings on face. Each rule has a thumb-indexed, illustrated manual to explain its operation in detail. Calibrations are in metric units.

Inflatable structures to balloon in space

At least half a dozen approaches to design of space stations, solar collectors, and other structures that can be transported in small packages and blown up in orbit are now being evaluated. They include spheres, torus and delta-wing shapes, and sphere-and-torus combinations. Some are made of relatively conventional materials like cloth and plastic film; others of new metallic and ceramic fabrics.

These structures offer a number of advantages. First, is packagability. A satellite 135 ft dia can be folded into a spherical container only 40 in. dia.

As Dr R. T. Ross of Goodyear Aircraft pointed out in his testimony to the House Committee on Science and Astronautics, a fabric structure has a million hinges built into it—and you don't have to pay for them, or provide cams and gears to activate them. Furthermore, a fabric structure has a natural "overload recovery." Under excessive load, instead of breaking or collapsing, it simply deflects, straightening out again when the load is removed.

Add to these, the light weight and ease of erection of such units and you have a structural system which, its proponents believe, rates even more attention than it's had so far.

Frangible conductive coating serves as fuse for safety lamp

A novel system to prevent accidental relighting of flame-safety lamps has been devised by a British firm. The "fuse" is simply a thin printed circuit—sprayed, painted or plated on the lamp bulb—that breaks when the glass itself breaks.

In this type of safety lamp, used for gas-testing in mines and other hazardous areas, there is a movable-filament, battery-operated relighter. It is built into the lamp and normally is protected from accidental operation by the bulb itself. If, however, the glass bulb is broken, gas may be admitted from the outside and an explosion may occur.

By incorporating a frangible metal conductor—the printed circuit on the glass bulb—in the relighter circuit, an automatic safeguard is provided. If the glass breaks, or even cracks, the circuit is broken and the relighter cannot operate. Wolf Safety Lamp Co, Sheffield, England, has patented the system, and has also developed an improved filament for lamps of this type which, it says, operates on minimum current because it has a platinum-ruthenium alloy that adds catalytic action to the electrical heating effect when the filament is brought into contact with the lamp fuel. —ARG

GLX-W COLUMBIUM-TREATED CARBON STEEL CUTS DEAD WEIGHT 10% IN NEW

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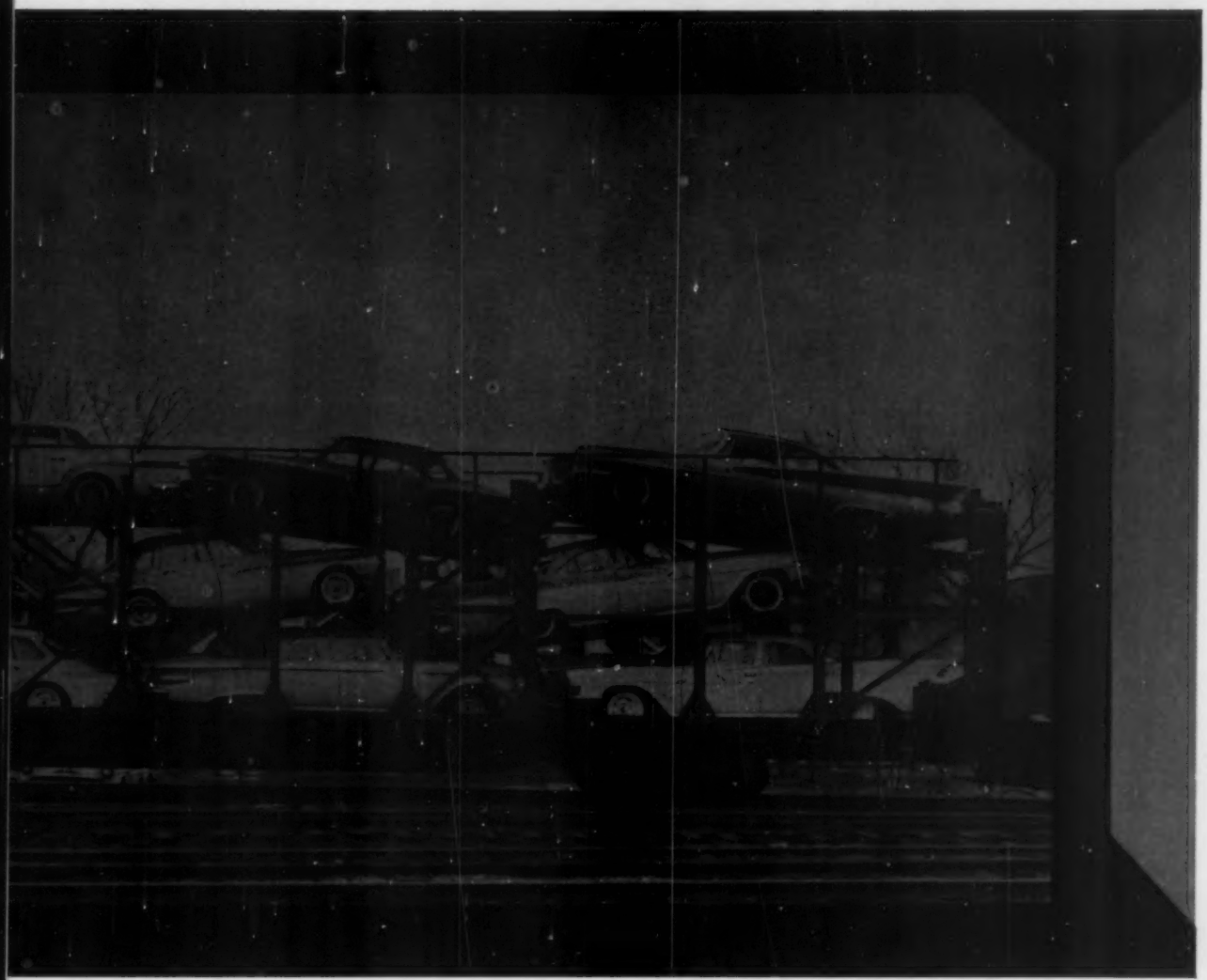
Bringing important new economies to rail shipment of automobiles, this new tri-level auto carrier holds twelve standard cars or mixed loads of 14 standards and compacts. Capacity is increased up to 75%. A unique system of hydraulically positioning the vehicles on three levels gives a clearance of only 16 feet 8 inches, permits use in areas formerly limited to bi-level unit operation because of clearance requirements. • Key feature of the Multi-Car Carrier is the movable decks on which the cars ride. Made of GLX-W columbium-treated steel, the decks are raised and lowered by built-in hydraulic lifts, actuated by a portable power unit. Here light weight was essential, in order to reduce the operating power requirements. Yet great strength was necessary, too, to support the payload. Finally, design of the decks called for eight bends in each section. So formability was also a must. • GLX-W met and exceeded all these requirements. It gives 50-100% greater strength than mild carbon steel, so builder Whitehead and Kales could get the required strength with less weight. Deck operating units need less power,

Great Lakes Steel is a Division of



Multi-Car Carrier built by Whitehead and Kales for Multi-Car Corporation, Detroit, Michigan

TRI-LEVEL AUTO CARRIER

and total weight is reduced approximately 5,000 pounds or 10%. Production is more economical, too, because the ductility and formability of GLX-W permits four of the bends in the deck to be performed in one press operation. ◆ The GLX-W series of high-strength steels consists of fine-grained, semi-killed mild carbon steels, treated with varying amounts of columbium. The high strength of GLX-W permits designers to reduce the amount of steel and effect considerable cost savings when replacing mild carbon steel. GLX-W steels have a low carbon content and are readily weldable and formable. GLX-W steels are available at four minimum yield strength levels: 45,000, 50,000, 55,000 and 60,000 p.s.i. and in sheets, plates and bars. For complete technical information, write Great Lakes Steel Corporation, Product Development, Dept. PE-9, P. O. Box 7310, Detroit 2, Michigan.

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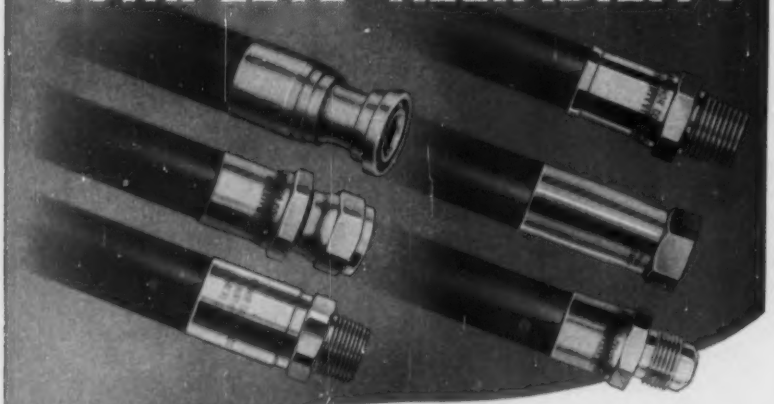

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READER TO EDITOR

Discussion of Dutch patent proposal

To the Editor:

In your June 10 issue p 12, under the heading, "From Washington" you state, "U. S. patent policy may follow Dutch proposal . . . Under the plan, patent applications would be published shortly after they were filed, but a patent would not be issued until a necessity for it is shown. For example, if the applicant needed the patent to enforce his rights, he would be able to call the case up for processing. . . . If need to process a patent application is not shown at the end of a seven-year period, the application will be abandoned."

After having filed more than thirty U. S. patent applications it is thought the foregoing arrangement would be open to wide discussion. I can comment only as regards my own experience in patent applications and in some instances the arrangement would not at all be feasible. For example, in 1939 an application was filed for a dispensing valve, a model of which functioned properly but still needed improvements, more models were made with modifications and each time, had to be tested for several months under various conditions. On this application a patent was issued in 1941.

From a marketing standpoint the valve was still not perfect and after a number of models were tested an application for an improvement was filed in Feb 1954. Although this was an improvement over the original the experiments continued and in July 1956 another improvement application was filed. This valve was first placed on the market in 1956, fifteen years after the original patent was issued.

If "the application is published shortly after it is filed," the inventor could be harmed in several ways, after the invention is disclosed to the public and without a patent anyone could manufacture and market the invention until a patent is issued, which would be from two to five years. It would be of interest to note other comments, for and against, the proposed procedure.

—G O Matter
Portland, Oregon

Correction

In the June 19 article "Stress When Curved Surfaces Touch" two equations were in error. For a cylinder on a cylinder stress $S_e = K_1G_1(P/D)^{1/3}$; for a cylinder in a cylindrical groove stress $S_e = K_1G_2(P/D)^{1/3}$. Also, the symbol P stands for load, lb/in., in all three of the cases involving cylinders.

Get the lead in

To the Editor:

We're always delighted to see an article like yours on battery power (Aug 14, p 5). Your article points out that the sealed battery now used in drills and razors rates 15.4 w-hr per lb and 1.6 w-hr per cu in. The comparable figures for an automotive lead-acid battery are 15.0 and 1.3; for an industrial type lead acid battery 13.1 and 1.35. On a cost per cycle basis, the industrial lead-acid battery is little more than half as expensive to use as the sealed type

you describe. And finally, where a sealed design is important, a lead dry cell may be used for low drains or, non-spillable aircraft batteries. —BRUCE FADER
Lead Industries Assoc
New York, N Y

COMING EVENTS

AUGUST

28-Sept 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee, Wisc

14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

25-28 . . . . American Welding Society, Fall Meeting, Adolphus Hotel, Dallas, Texas

OCTOBER

9-11 . . . . Institute of Radio Engineers and AIEE, National Electronics Conference, International Amphitheater, Chicago

9-13 . . . . Society of Automotive Engineers, National Aeronautic Meeting, The Ambassador, Los Angeles

15-20 . . . . American Institute of Electrical Engineers, Fall General Meeting, Statler-Hilton Hotel, Detroit

17-19 . . . . American Society of Lubrication Engineers, and ASME, 8th Annual Lubrication Conference, Morrison Hotel, Chicago

19-20 . . . . Illinois Institute of Technology and Armour Research Foundation, 1961 National Conference on Industrial Hydraulics, Sherman Hotel, Chicago

19-20 . . . . American Society for Quality Control, 16th Midwest Conference, Chase-Park Plaza Hotel, St. Louis

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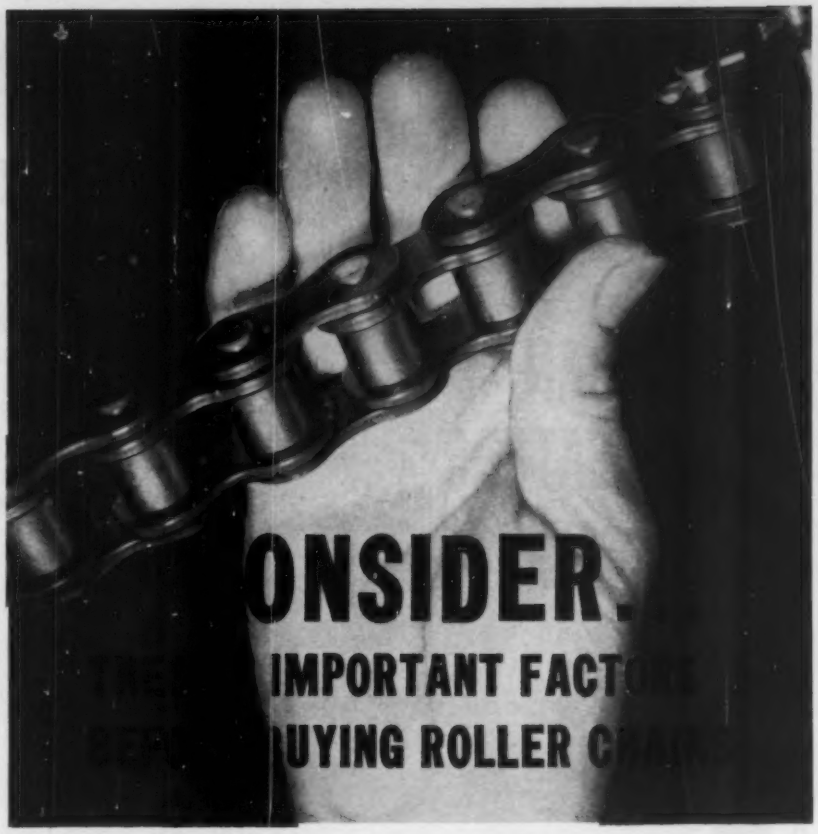

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FOR YOUR INFORMATION (personal)

Fair warning for motorists

A little plastic plate that can be hung on mirror or dashboard is ready to warn the unwary motorist of dangerous carbon monoxide fumes. The plate is about 2 in. square, and carries a dime-sized insert of an indicator compound (palladium chloride suspended in silica gel). Initially, the indicator, and the plastic plate, are buff-colored. But, when carbon monoxide is present—even in concentrations as low as 0.01%—the chemical changes color, turning dark gray or black, as the carbon monoxide reduces the palladium salt. When the CO concentration reaches 0.05%, the change is almost instantaneous. Made in Denmark, the device is being marketed here by Hi-Detectors, Box 202, 238 E. 86 St, New York 28. Price: 50¢ each, postpaid.

This gas control does everything but talk

A gas control that will hold oven temperatures as low as 140 F; "walk" roasts automatically, just as a chef does, to bring out latent heat; and has a pilot light and 100% shutoff for "complete safety" is to be introduced by Wilcolator Co for 1962-model ranges.

With the new temperature control, says Wilcolator, the housewife can place a frozen roast or casserole in the oven, set the controls for slow or fast defrost, follow it by heating at exactly the right temperature to produce the desired degree of cooking, and hold the oven at the heat required to maintain this result for whatever period may be necessary. All of this, without touching the range more than once.

No pipe or fittings are necessary to the thermostat; Wilcolator claims, and bell, buzzers or chimes may be substituted for the indicating lights. Furthermore, there is no critical re-ignition of the burner and no time lag in thermal response.

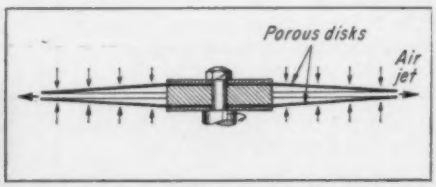
Furthermore, its designers proudly claim the new temperature control system is compact and easy to assemble, and should permit substantial savings to gas range manufacturers.

A fan for your air conditioner

A saucer-shaped fan that's specifically designed to sit in front of your air conditioner, pick up its cold air, filter it, and shoot it out around the room, is being marketed by Chemex Corp, 41 Murray Street, New York 7. The fan will even shoot the air around a corner, its designer says, and will give radiators an assist in winter, too.

In place of the usual propeller blades, the unit has a rotor assembly that combines an arbor, 5 impeller disks, separated by spacers, and top and bottom plates. Filtering action is achieved through paired, replaceable porous filter disks, which Chemex claims, help to create the air jet as well as clean it. Says Chemex: As the unit rotates, the porous disks create and maintain a vacuum in the space between them so that air is sucked in and filtered. Then, the filtered air is centrifuged to the periphery and leaves through a 360-degree "lip" (see diagram) which, against the pressure of the atmosphere, "opens like a valve for one-way flow."

The model shown, 16 in. in dia, weighs 7 lb, has a power consumption of 100 watts, is priced at $50. —ARG



BLADELESS FAN has molded plastic housing, filter disks which aid jet action. Air sucked in through porous disks is expelled at the periphery, with edges of disks forming a one-way valve.

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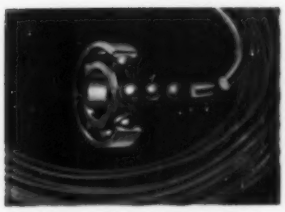
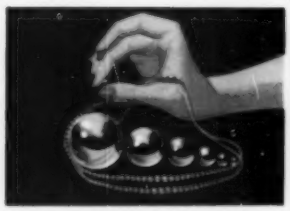
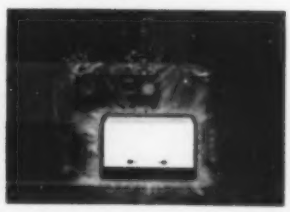


High quality wire from which balls are made is produced by Hoover's Cuyahoga Steel and Wire Division.



Hoover *Micro-Velvet* Balls are made of the finest of chrome alloy steel. Sphericity is measured in millionths of an inch.

It's easier to strike a match on plate glass than on the smooth finish of a *Hoover Honed* bearing raceway.



Hoover quality control methods include non-destructive electronic inspection of bearing components.

Roller Cam Action of Over-Center Clutches Reduces Wear, Pressure and Adjustments

Rockford exclusive anti-friction roller cams increase clutch life, lower pressure needed to engage and release, and reduce clutch adjustments. Precision-ground, hardened steel rollers force pressure plate against facing and flywheel for smooth, powerful engagements. Actuation progresses from "release" to "on-center" to the slightly "over-center" locked position. Operated by hand lever, Rockford Over-Center Clutches remain in or out of engagement until changed by the operator. Clutches fit flat or counterbored flywheels. Oil or dry operation. Torque loads from 365 to 3,000 lb. ft. Write today for illustrated brochure.

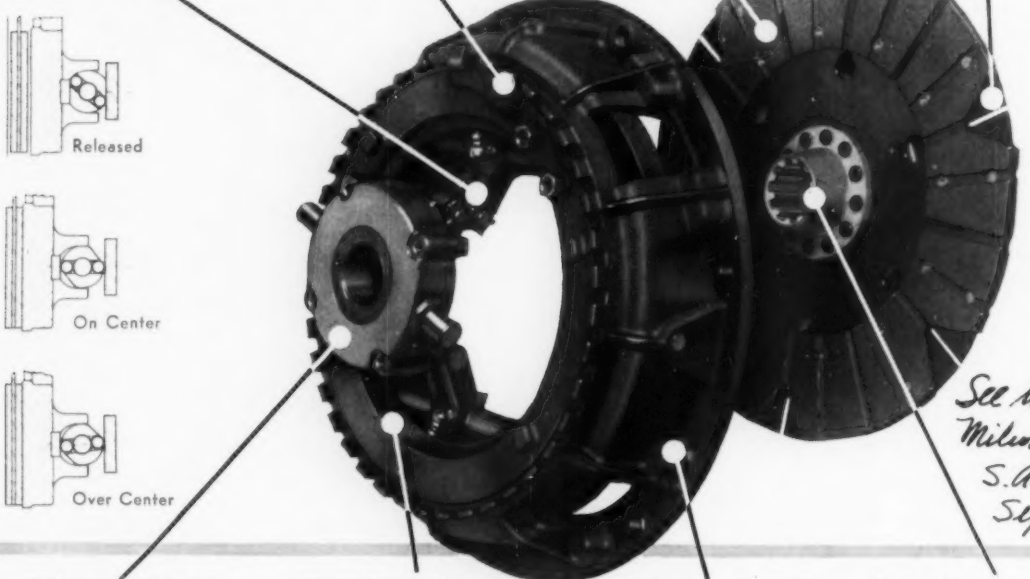
Allis-Chalmers Crawler equipped with Rockford Over-Center Clutch

Patented anti-friction roller cams reduce wear, adjustments, and lever pressure. Slight pressure to rollers forces pressure plate and facing against flywheel, instantaneously locking and engaging clutch.

Positive-lock adjusting ring allows fine adjustments for longer life and smoother starts. Simply release lock and turn to exact engaging position. Positive-lock prevents "creeping". Adjustments are long-lasting.

High-test facings give extra-long clutch life, reduce scoring, and greatly cut costs of downtime, replacement and labor. Strong, lightweight construction permits easy shifting and braking.

Segmental slots prevent "dishing" . . . even under extreme heat conditions. Rotary surface grinding assures perfect, uniform flatness. Core plate is made of special high-carbon spring steel.



See us at the Milwaukee S.A.E. Show Sept. 11-14

Release bearing assembly consists of bronze or ball bearings. Clutch is actuated from hand lever to yoke contact on trunnions. Pivot pins give direct, smooth actuation between release sleeve and cam arms.

Spring steel plate, bearing against roller cams, yields slightly upon actuation. This assures extremely smooth engagements, relieves cover plate of strains, maintains uniform pressure, and gives longer life.

High tensile strength cover plate assures safe operation. Compact, low-inertia design prevents gear clashing and delayed shifting. Dynamic and static balancing of each clutch eliminates vibration.

Close-tolerance splined hub assures perfect disc alignment. Through-hardened hub gives long life. Bolt circle and pilot dia. accurately locate cover plates. Precision manufacturing eliminates misalignment.

ROCKFORD CLUTCH

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ROCKFORD BW CLUTCH DIVISION OF BORG-WARNER

PRODUCT ENGINEERING HORIZONS

AUGUST 28, 1961

Dear subscriber:

The Design Digest Issue of September 4 will be the last weekly issue of Product Engineering; thereafter we will appear every other Monday—on a bi-weekly cycle beginning September 18.

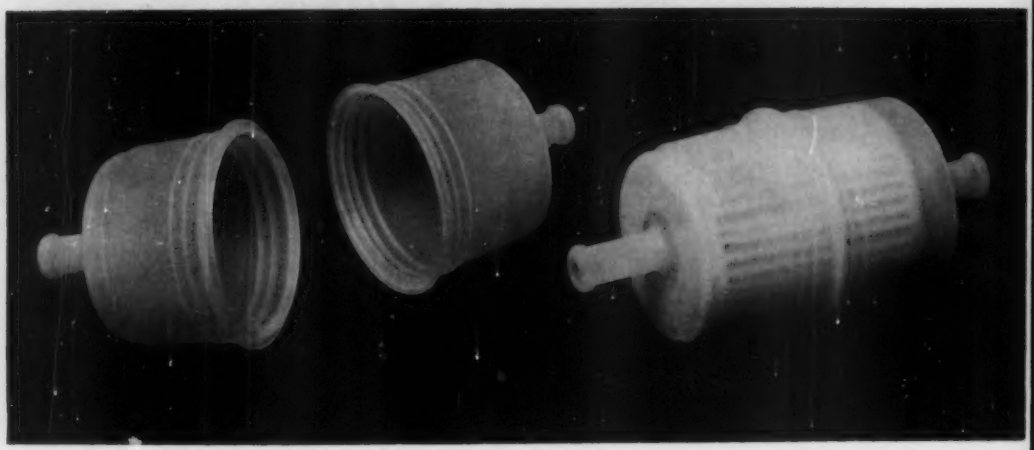
This decision was made, of course, after a great deal of study and deliberation.

Our experience has taught us a great deal about your changing requirements, has led us to pioneering in such fields as the broad-based engineering news roundup, the show report, the special report, the opinion survey, and such original departments as Developments to Watch, What's Happening in Research, Interesting to Note, Trends in Industrial Design, Why Don't They R & D?, For Your Personal Information. We have added price and delivery information in new-product descriptions, increased coverage of such items. We have also undertaken the massive job of rewriting and editing for maximum readability in minimum space, to save your time. And we have offered help in reading, report writing, note taking and public speaking. Several of these have been recognized by journalism and public-service awards—three last fall.

That you have appreciated our editorial service is indicated by the increase of our paid circulation from 37,000 to 51,000. The fact that more readers renew their subscriptions at expiration, and much increased reader response are additional evidence that our service to design engineers is appreciated.

Our new frequency, however, offers several advantages. It will make possible further improvements in format, presentation and illustrations, as well as more-comprehensive, better-balanced coverage in each issue. We feel that we can provide a new and far superior standard of service under the new conditions, and that our new "package" will be outstanding.

We'd very much appreciate your comments about the new magazine after you've had a chance to read through the first issue or two.



1

Spinweld to join thermoplastic parts

Simple fixtures and standard drill-press equipment are all that is needed in this high-speed technique for assembling plastic materials. Production rates up to 60 welds per min are practical, but process is limited to thermoplastic parts with circular joint shapes.

R L MILLER and D M THOMPSON, *technical representatives*
Polychemicals Dept
E I du Pont de Nemours & Co

■ Spinwelding is a fast, cheap method for joining plastic parts with circular mating surfaces. Consistent, high-strength joints are produced by spinning and rubbing one part against another to generate welding heat. Friction heat rapidly melts a thin surface layer, leaving that layer and the material beneath relatively unchanged. Result is a hairline weld needing no filler material and causing little or no distortion of the joined parts.

Any true thermoplastic can be spinwelded, including polyethylene, acetal, acrylic, nylon and fluorocarbon resins. Strength of the weld varies somewhat with the plastic but joint efficiency is at least 80% that of the strength of the parent material.

Spinwelding dissimilar plastics generally produce low-strength joints. Where permissible, such joints should be designed with undercuts so that melt flows into the undercut to form a mechanical interlock.

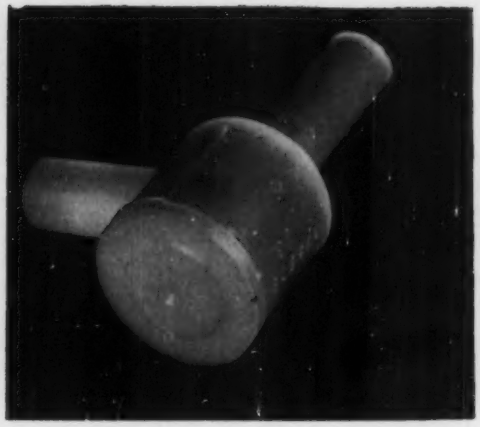
The rubbing-welding technique

Basically the process rubs a rotating part against a stationary part. Friction generates heat and melts the contacting surfaces, and pressure is applied to squeeze out any bubbles. Spinning is then stopped but the pressure maintained until the weld solidifies.

The heat built up at the surface depends on the friction coefficient of the material and its heat conductivity. Temperature of welding is controlled by changing relative velocity of the two surfaces, contact pressure and time of rubbing contact.

Surface velocity should be at least 20 surface ft per sec. Speed should be relatively uniform across the joint so that heating is uniform. This means that solid parts with large diameters should be welded on a land at the circumference rather than across the entire area. Because speeds greater than 5000 rpm are usually not recommended for standard rotating equipment, welds with diameters less than 1 in. require greater contact pressure or longer rub times to build up the necessary heat.

Contact pressure during spinning should be approximately 200 psi for most materials. Pressure during solidification should be 100 to 200 psi. This is usually sufficient to force any bubbles or contamination from the



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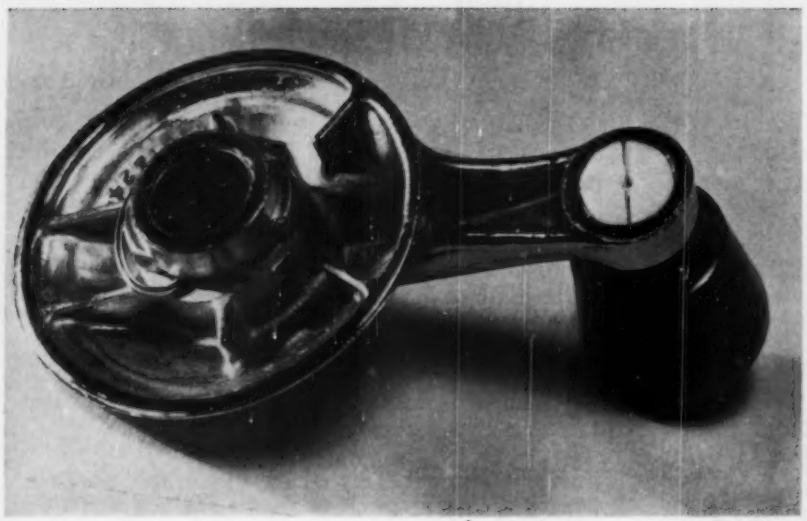


4

1 SHELLS WELDED TOGETHER enclose filter element. Made of nylon, the body resists corrosion by impurities in the fuel it filters.

2 END CAP HERMETICALLY SEALS and assembles seat and ball in check valve. Delrin acetal resin is readily welded by this method.

3 ACRYLIC LENS AND REFLECTOR are molded as separate parts. Internal refracting and reflecting surfaces stay clean when sealed-in by welding.

4 PLASTIC KNOB IN AUTO WINDOW CRANK is attached by welding on retaining button. Plastic-to-plastic joint allows knob to rotate within metal crank.

joint. Polyethylene is an exception. It can be welded at 50 to 100 psi.

Quick braking or stopping of the part is essential to the process. Once sufficient melting has occurred, motion must stop to allow the melt to solidify. If movement does not stop quickly, it will shear the weld. Relative motion can be halted by an electric brake on the motor or built into the design of the driving tool.

Short weld time decreases flash and localizes heat at the rubbing surfaces for minimum residual stress and distortion. Usual practice is to spin-rub parts for about ½ sec at the recommended surface speed. Over-all time including handling—about 1 to 2 sec—allows a production rate as high as 60 pieces per minute.

Joint Design

Joint shape should provide maximum weld area and keep uniform temperature across the entire joint.

• Weld areas on butt joints can be increased by modifying them with steps, scarfs or tapers. In addition, these shapes discourage crack propagation by forcing them to follow a crooked path rather than a straight one. Typical joints for thick and thin walls are shown on the next page.

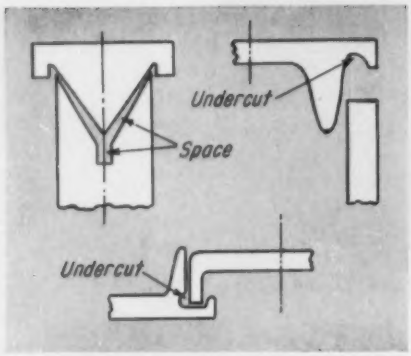
• Heat is kept uniform by minimizing variations in surface velocity. In thin-walled cylinders heat distribution is usually no problem but in a solid shape such as a disk, it may be necessary to cut away the center portion of the weld. This can increase joint strength in small-diameter parts even though weld area is decreased. An alternate method of keeping temperatures uniform in solid pieces is to crown the center portion so that it rubs and starts to melt before the outer portions make contact.

Dimensional tolerances of the contacting surfaces at the joint is ±0.002 in. per in. of diameter.

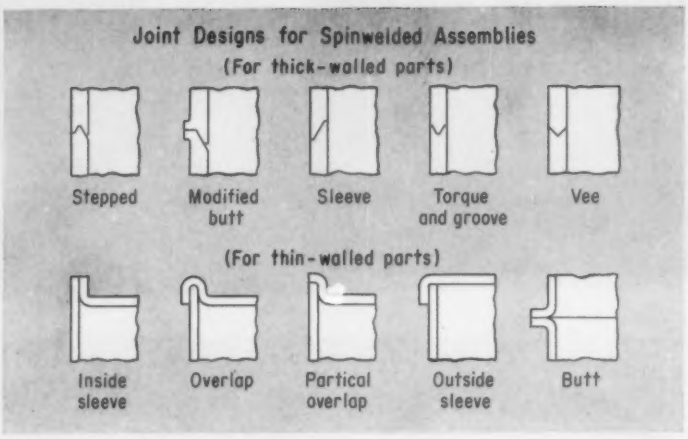
Spinweld joints are continuous and form good hermetic seals. By proper design, they can be stronger than the rest of the part. Where sealing is not wanted, as much as 15% of the joint can be undercut to remain unwelded.

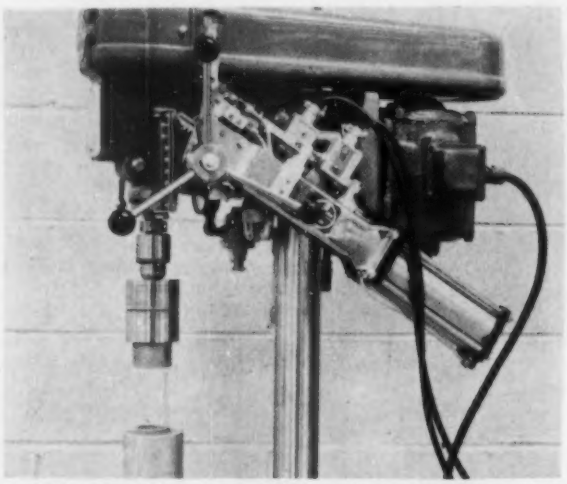
Controlling flash

In spinwelding, the excess melt is forced from between the mating surface in the form of a thin flash. In a



UNDERCUTS HIDE FLASH to eliminate trimming. These three designs show how to include space or relief within the joint.





COMPLETE UNIT adapts drill press for spinwelding. Made by HyPneuMat Inc, Milwaukee, Wis, attachment includes timer control, pressure cylinder and brake.

manual setup, flash is helpful because it proves that surface melting is sufficient for a good weld. But flash should be kept to a minimum to avoid interference with mating parts. This is especially important for hollow containers where the shape precludes trimming flash on the ID.

Joint can be designed so that it will retain flash within undercuts and pockets. Other designs force the flash in one direction—to the ID where it cannot be seen or to the OD where it can be easily trimmed.

Proper joint alignment and minimized spin time will decrease flash because little material has to be melted and displaced. This alignment requires good joint tolerances, and positioning the parts in accurately made fixtures. High speeds and pressures cause more flash and tend to throw it outward.

Driving tools for spin-welding

Two types of tools have been developed for this process. For joints with areas less than ½ sq in. the arrangement consists of a spring-loaded pivot pin that bears on the part and maintains pressure after the driving teeth are disengaged. For large joints the inertia tool gives better weld reproducibility. Here a flywheel is accelerated to speed and engaged into the part. After the flywheel slows to below a given speed, a clutch disengages it so that the total weld energy is constant.

EDITOR'S NOTE: Other recent articles on techniques for forming unusual shapes from plastics and how to design parts for these processes:

Closer Look at Fiberglass-reinforced thermoplastics, May 15 '61, p 95—Adding glass fibers to thermoplastics strengthens them for shapes that must carry high loads.

Design Polycarbonate Parts This Way, May 1 '61, p 46—Here are the do's and don'ts of design for high-strength parts of Lexan polycarbonate resin.

Blow Molding Goes Industrial, Jan 16 '61, p 50—For thin-walled parts, this fast-growing process offers a new way to produce flexible or rigid shapes.

High-impact Phenolic Molded Parts, Mar 7 '60, p 54—Design criteria for fiber-reinforced phenolics are different from those for unfilled versions. Article gives rules for these plastics which compete with metals where shock loads are a problem.

Better Linear Polyethylene Moldings, Mar 16 '59, p 55—Formerly considered difficult to mold, this family of plastics can be easily molded if design is guided by these suggestions.

Selecting Plastics Laminates for Punching, Feb 2 '59, p 57—Laminate choice must be based on ease of fabrication as well as mechanical or electrical properties.

Where Vacuum Forming Stands Today, Dec 22 '58, p 56—Variations including air-stretching and match-plate forming to make deeper parts, more complex designs.

For Better Phenolic Molded Parts, Sept 1 '58—How to get the best results from this thermosetting plastic.

Postformed Phenolics, Feb 17 '58, p 66—How to shape prelaminated sheet stock for economical parts that are as good or better than molding and laminating simultaneously.

—Herbert Kee

MAGNETIC CLUTCHES

for continuous slip

Magnetic-particle, hysteresis, and eddy-current clutches are your choice for continuous-slip applications. Here's how they operate, their relative strengths and weaknesses.

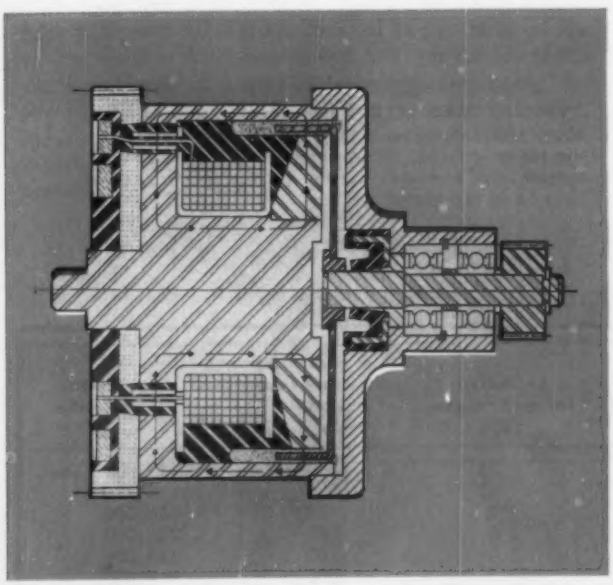
D L SWORDS, *application engineer*
Lear Inc, Grand Rapids, Mich

■ Friction clutches are at a disadvantage in continuous slip applications—particularly at the instrument and control level, where operation must be exceptionally smooth and chatter-free. This disadvantage is inherent; it can be compensated for, but it cannot be eliminated as long as the clutch members are required to rotate at different speeds. Further, the torque output is dependent on operation speed and the coefficient of friction—which is affected by temperature, humidity, surface contamination and a number of other uncontrollable variables—is generally critical.

These particular limitations are minimized or eliminated in magnetic clutches (true magnetic clutches, that is, as distinguished from solenoid-actuated friction clutches). Three common types are available although only the first two are in general use on the instrument and control level.

- Magnetic-particle
- Hysteresis
- Eddy-current

Each type, of course, has limitations of its own. The seals required in the magnetic-particle type cut down clutch speed and service life, and impose a relatively high residual drag. Hysteresis clutches are bulky. Eddy-current clutches are speed sensitive. The stability of all three types can be upset by changes in coil resistance at high temperatures. All three require a special dc supply, and some sort of control circuitry.



Magnetic-particle clutch

MAGNETIC-PARTICLE CLUTCH

The magnetic-particle clutch is the most versatile of the three. It lends itself easily to a variety of general applications, without special modification. Standard units, including duplex models, are available in a wide range of stock sizes down to the subminiature. The few milliamps of dc excitation needed for control can usually be handled by miniature electron tubes or transistors in conventional circuits.

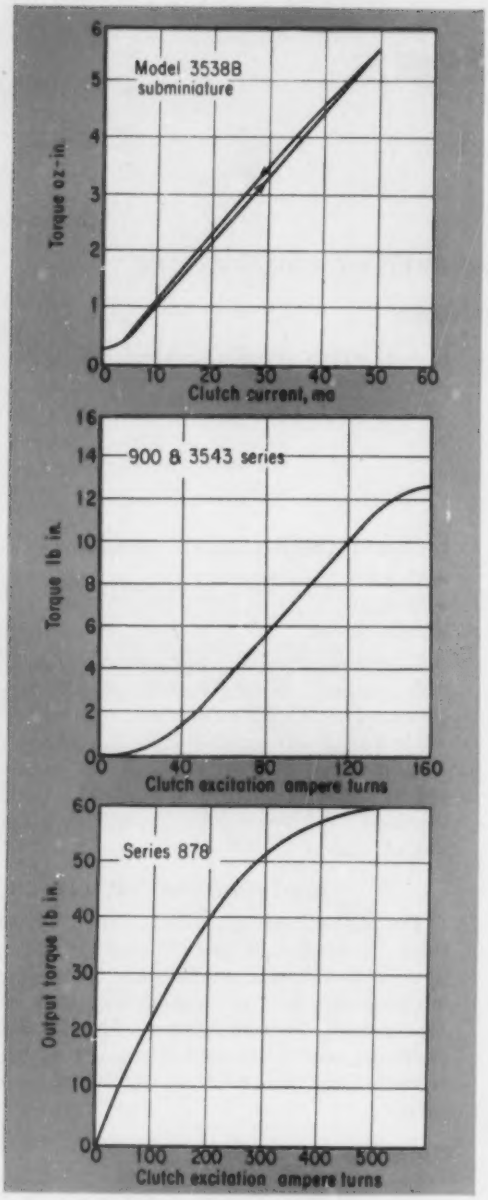
Operation

The control medium—a fine powder of uniform magnetic particles mixed with a dry lubricant—is sealed in an air gap between two clutch members. When the clutch coil is energized, a magnetic field is induced through the air gap; the individual particles in the medium are magnetized and tend to cling together in seemingly solid "chains" along the lines of flux; as these chains grow into and across the gap, the two clutch faces are effectively coupled. In simple power applications, where constant slip is not required, the chains behave as rigid spokes between the members; in constant slip operation, they shear continuously. This produces a drag torque between clutch members. The amount of torque produced is determined by the shear strength of the "chains," which varies with the density of the magnetic field, up to saturation. Slippage normally takes place only between lubricated particles

REPRINTED—Circle 628, inside back cover

at the center of the working gap, so that the actual clutch surfaces are protected by an immobile layer of the finely divided powder.

Magnetic-fluid clutches are designed to operate on the same principle, but with magnetic particles suspended in an oil. This, indeed, was the original approach. In theory it is sound—a wet clutch may be expected to operate more smoothly than a dry one. In practice, unfortunately, a number of so-far insurmountable problems have arisen to stymie development. Probably the biggest headache is the problem of sealing fluid in the working gap, but behind that problem lie a number of others. For example, the drag torque of these units tends to vary widely and more or less unpredictably as the viscosity of the oil changes with temperature in what has to be a normal operating range. In continuous-slip operation, furthermore, internal clutch temperatures rise to levels that can cause oil breakdown and coking. Dry magnetic powder offers an imperfect but workable compromise solution. Few magnetic-fluid clutches are in production today.



TYPICAL MAGNETIC-PARTICLE torque curves show how individual models can have quite dissimilar curves. Single curves (middle and bottom) are averages—actual plots show hysteresis loop as in top curve.

Performance

The characteristic output torque vs coil excitation curve of the magnetic-particle clutch is essentially linear over most of its range, although there is generally some nonlinearity either as it approaches the saturation level in one direction, or the zero-excitation point in the other. In many units both ends of the characteristic curve are nonlinear. Most of these nonlinearities can be eliminated simply by maintaining a small quiescent current in the control coil. Typical curves are shown at left.

Note that these curves are actually simplifications of narrow hysteresis patterns, typical of all electromagnetic clutches. They indicate that the torque value obtained at a given level of coil excitation, while the magnetic field is building toward saturation, is not the same as that obtained at the same level when the field is being collapsed. Characteristics of different models differ in detail, but as a rule the actual width of the hysteresis loop is between ±5% and ±10% of the nominal value. Repeatability of torque for a given current level is within 2 to 5%.

TYPICAL MAGNETIC PARTICLE CLUTCH PERFORMANCE DATA

Diameter (in.)	Weight (lb)	Max torque (lb-in.)	Max Speed (rpm)	Excitation for max torque (w)	Max continuous frictional heat dissipation (w)	Torque-to-inertia ratio (rad/sec²)
0.6	0.055	0.3	1000	0.75	0.2	111,500 (rotor)
1.155	0.34	0.95	2500	1.25	5	2,200
2.358	2.4	18	2000	1.0	15	316,000
3.165	3.5	60	3400	4.0	75	250,000
4.0	7.6	160	1500	3.0	60	188,000
10.0	80	1900	1000	11.5	500	19,000

Response of these clutches is independent of operating speed. It depends, in large part, on the control circuitry. It is fastest when the control source has infinite impedance, slowest—three times as slow, in most cases—with zero source impedance. Other factors that affect the speed of response include: coil configuration, magnetic materials employed, size and number of air gaps in the magnetic path, and particle dynamics.

It is convenient to specify response speed in terms of "torque time constant," which is defined as the time required to produce 63% of maximum rated torque as measured from the leading edge of a step current input equivalent in magnitude to the rated maximum excitation. The torque time constant for each model is the summation of three component constants:

- **An electrical time constant,** which can be reduced significantly either by increasing the impedance of the driving source or by pulsing or overpowering the coil.
- **A magnetic time constant,** which can be set in design by proper choice of configuration or materials.
- **A mechanical time constant,** which reflects a transient condition that exists while the particles migrate to the working gap and align themselves across it. This condition is a function of the gap geometry and flow characteristics of the powder. In some designs it becomes dominant.

Standard torque time constants can run as low as 7.5 millisec, for subminiature sizes. Nominal ratings for larger units are proportionately higher.

Advantages

For all practical purposes, the torque output of a magnetic particle clutch may be considered independent of its operating speed. This characteristic is generally regarded as a primary advantage over the friction clutch, with its familiar, troublesome inverse relationship between output speed and torque capacity.

Several other characteristics of the magnetic particle clutch are particularly desirable in continuous-slip use:

- As we have noted, torque varies linearly with excitation current over the working range.
- Because the clutch surfaces themselves are protected from wear, with all slippage confined to the center of the working gap, no adjustment is required over the life of the clutch. Thanks to improved techniques for sealing the powder in the gap and protecting it from contamination, life is now usually specified at a minimum of 1000 hr uninterrupted duty under maximum continuous frictional heat-dissipation conditions.
- Unpredictable transient changes in the coefficient of friction between contact surfaces have been minimized. Operation under continuous slip is quiet, with no tendency to grab or chatter. Torque stability, on the whole, is good.

Limitations

Although torque is independent of operating speed, slip speed is a controlling factor. The rate at which either clutch member rotates is not significant in determining clutch size (as long as it falls within specified limits) but the speed differential between the two members is critical. In this respect, the magnetic-particle clutch is no different from any other: when it slips, kinetic energy is converted to heat energy. The more it slips, the hotter it gets. Resulting temperature rise affects output torque in three ways:

- Coil resistance rises with internal temperature (major effect). This reduces flow of current through the coil, which diminishes flux density through the working gap, which weakens the shear resistance of the magnetic "chains," which decreases torque output of the clutch. If constant current is not maintained, the clutch dissipates less power for a given voltage, therefore temperature is reduced. The clutch automatically protects itself against high temperatures.
- The coefficient of friction between the magnetic powder particles decreases under the heat, lowering the torque output and aggravating the temperature rise (side effect). While the effect on operation is less severe than in a conventional friction clutch, it nonetheless impairs performance.
- Metal expansion may change the size of the working gap, further reducing torque stability (side effect).

The cumulative effect of the three factors is usually a 20% drop in clutch torque as internal temperature rises from ambient to rated maximum, although this change can be held to less than 5% with a fixed current input.

Be sure that the clutch you specify can handle the frictional heat it will be required to dissipate. In instrument sizes, magnetic particle clutches are customarily rated in "watts maximum continuous frictional heat dissipation due to slippage," while large units are generally rated in horsepower. The amount of heat your clutch will have to dissipate can be calculated by the following formula:

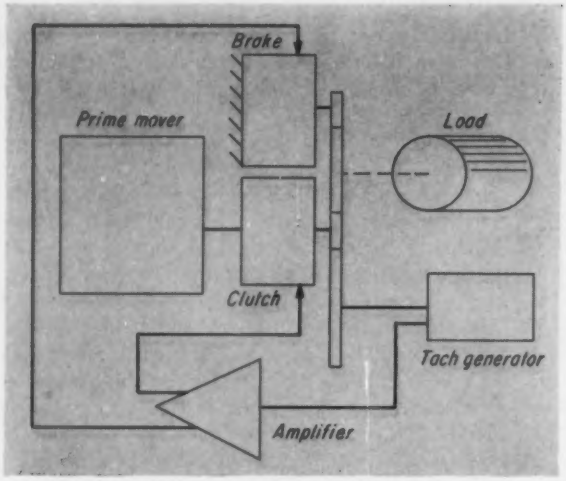
Frictional heat = Slip speed x Slip torque x 0.01184

where frictional heat is expressed in watts, slip speed (relative speed between clutch members) in rpm, and slip torque in pound-inches.

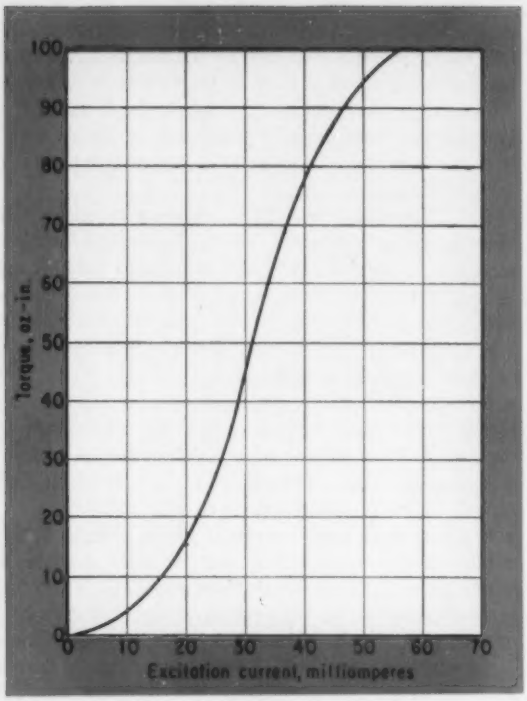
Remember that most catalog ratings are based on the

TYPICAL HYSTERESIS CLUTCH PERFORMANCE DATA

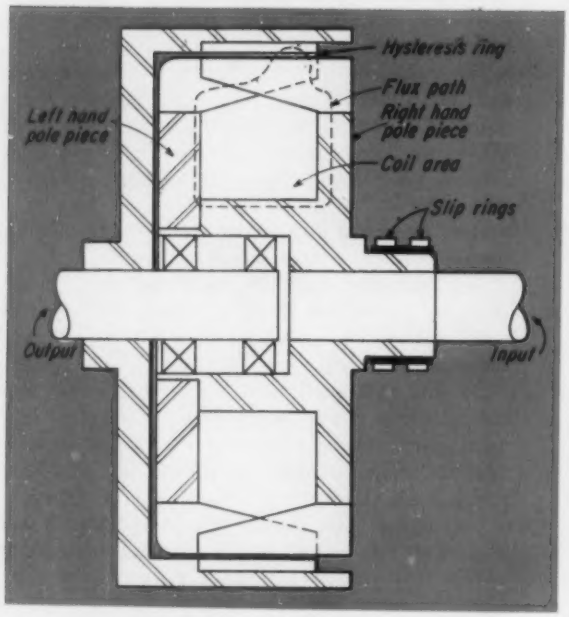
Diameter (in.)	Weight (lb)	Max. torque (oz-in.)	Max speed (rpm)	Control power for max torque (w)	Max continuous frictional heat dissipation (w)	Torque-to-inertia ratio (rad/sec²)
1¾	0.5	6	5000	3	20	20,000
2	0.65	16	3600	5	20	26,000
2⅛	1.1	32	3600	6	25	25,000
3⅜	4.75	100	3000	5	40	9200
5½	12.3	300	2500	7	60	3500



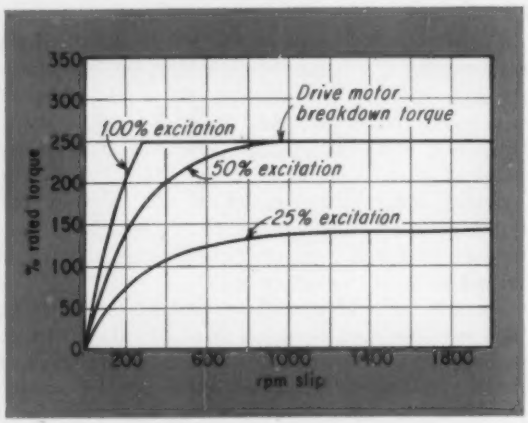
Typical speed control system, magnetic particle clutch



Typical hysteresis clutch torque curve



Hysteresis clutch



Typical eddy-current clutch torque curve

arbitrary standardization of four variables: controlled speed, torque output, ambient temperature, and mounting conditions. It is advisable to work fairly closely with your supplier when specifying a clutch for a continuous slip application, since a small deviation from any of these basically artificial conventions can seriously upset the performance of the clutch.

The same general rule that applies to conventional clutches applies to these: all other things being equal, the larger the unit, the greater its capability of dissipating heat. All other things are only occasionally equal, however, and many modern control applications require the selection of the smallest, lightest, fastest unit that can possibly do the job. Three standard methods will improve heat dissipation capabilities within a given size:

- Cooling fins are added to increase the area of dissipating surface.
- Maximum operating temperature of the unit can be more than doubled and wattage rating multipled by a factor of 10 or better with special high-temperature coil insulation and potting materials.
- A liquid cooling system is employed. This method is most common with power clutches of integral-horsepower size, but it is sometimes called for on the instrument level as well.

There is another limitation inherent in these clutches that demands careful consideration. It is described in the catalogs as "drag torque at zero excitation."

All clutches exhibit some residual drag, if only as a result of normal bearing friction and windage. Magnetic-

particle clutches add to these particle drag and seal friction. In most large and intermediate sizes drag friction is insignificant, running from 0.5 to 1.0% of maximum torque for breakaway drag, and from 0.25 to 0.5% of maximum for running drag, measured at zero excitation and 500 rpm. In subminiature models, running drag run as high as 10% of maximum torque. This value is unaffected by normal changes in environment.

Control

Magnetic-particle clutches are externally controlled, and provision must be made for their regulation. The type of control is determined by the application.

A potentiometer can be used in applications that demand only that the clutch supply a predetermined slip torque to be set by an operator. This control is used on winding machines, where tension must be regulated manually to suit various materials and material sizes, and on torque wrenches, where maximum output is varied according to assembly instructions.

For automatic control, a switching network may be sufficient. In a typical example, switches are connected to tap various excitation levels when actuated by the motion of the machine. Or the control may be a potentiometer mechanically driven by the machine as it goes through its cycle. Tape timers and electromechanical timers can also be used.

When the clutch is a speed controller, error signals can be generated by an ac or dc tachometer, connected through an amplifier as shown at left.

Mounting

The heat-transfer path from a continuous slip clutch to its surroundings must be unobstructed. Good radiation and convection are expected in the manufacturer's ratings. Whenever possible, the clutch should be mounted on a structural member sufficiently large to allow additional heat dissipation by conduction. In difficult applications, forced-air or water cooling may be necessary.

HYSTERESIS CLUTCHES

Hysteresis clutches offer smooth action and close torque control unaffected by environment, slip speed or aging. They work well in continuous-slip service, and are frequently used in winding machines, dynamometers, and sensitive drilling machines. They are at their best in the smaller sizes—at torque ratings down to ounce-inches. They tend to grow bulky at ratings over 1 hp, and their relatively low amplification ratio (about 15:1) becomes a handicap.

Operation

Basically, a hysteresis clutch consists of a high-hysteresis steel rotor spinning in a rotating magnetic field. There is no mechanical coupling between the clutch members. In a typical instrument, a high-hysteresis, hard-steel outer member surrounds a slightly smaller magnetic rotor, in which the control coil is housed. When energized, the coil creates magnetic poles on the magnetic driven member (rotor); these poles induce corresponding poles within the constant-speed steel driving member; once established, the two sets of poles resist any force that might change their alignment, so that the two members tend to rotate synchronously, as if directly coupled. By varying the level of excitation on the coil, the clutch can be forced to slip, producing a variable torque.

Performance

The characteristic torque vs excitation curve of the hysteresis clutch is similar to that of the magnetic particle clutch. That is, it is essentially linear over most of its range, with small deviation as it approaches the zero-excitation and the saturation points. A typical curve for a unit rated at 15 w is shown at left. The actual curve, of course, is in the form of a narrow hysteresis loop. Torque control is extremely close, $\pm 1\%$ for a given current level.

Advantages and Limitations

The hysteresis clutch offers the same advantages as the magnetic particle type, when compared with friction clutches in continuous slip operation. Briefly, these include:

- Torque output independent of speed
- Torque varies linearly with excitation
- No wear, no adjustment during service life
- Chatter-free operation
- Good torque stability

Again like the magnetic particle clutch, heat dissipation is a major problem. Torque stability can be upset by temperatures high enough to alter the resistance of the control coil. And metal expansion may change the size of the working gap, further reducing torque stability.

The hysteresis clutch and the magnetic-particle clutch offer basically similar performance. In many continuous-slip applications the two types may be considered alternatively.

Most advantages of the hysteresis clutch over the magnetic-particle type are relative, rather than fundamental. In tight decisions, however, they may prove compelling.

Hysteresis clutches present no sealing problem. Although seals for magnetic particle clutches have been improved considerably, they are still the determining factor in the life of the clutch. Potential service life of a hysteresis clutch, therefore, is significantly greater.

Linearity of a hysteresis clutch is usually slightly better than of a comparable magnetic-particle clutch, and performance is a bit smoother because no mechanical control medium is introduced into the working gap. Response is about the same for both types. Idling drag in these units is negligible.

These relative advantages must be weighed against certain clear limitations. The hysteresis clutch is bulky; a magnetic-particle clutch of the same torque rating, with closely equivalent sensitivity, can be supplied in a much smaller and lighter package. Magnetic particle clutches, moreover, offer a decidedly superior amplification ratio.

EDDY-CURRENT CLUTCHES

Eddy-current clutches are limited in application by their speed-torque characteristics and by the high temperatures they generate in continuous slip. Like the other two magnetic clutches, they give smooth operation and accurate control, but other characteristics are fundamentally different. Most electrically controlled types are highly specialized for limited applications, although fairly versatile permanent-magnet types are now available. They offer excellent

TYPICAL EDDY-CURRENT DRIVE PERFORMANCE DATA

(Clutch in standard fractional hp package with constant-speed motor and speed control)

HP	Dia. (in.)	Weight (lb.)	Max Torque (lb-in)	Speed Range (rpm)	Full-load Current (amp)	Phase	Max Continuous Frictional Heat Dissipation (w)
¼	6½	48	9	1650–65	3.6/1.8	1	186
					1.3/0.65	3	
½	6½	50	9	3200–130	8.0/4.0	1	362
				3300–130	1.8/0.9	3	
			18	1600–65	7.0/3.5	1	
					2.2/1.1	3	
¾	6½	51	13.5	3100–130	8.8/4.4	1	548
				3300–130	2.4/1.2	3	
			27	1550–65	3.2/1.6	3	

Note: Typical clutch unit, rated for ¾ hp at 1800 rpm or 1½ hp at 3600 rpm, measures 7 x 8 x 13½ in., requires excitation of 1 amp at 40 v or 0.38 amp at 90 v. Time constant is 0.20 sec.

service in power applications, but are seldom used on the instrument control level under consideration in this article.

Operation

In basic construction, an eddy-current clutch is so similar to a hysteresis clutch that a single cross-sectional drawing can be used to illustrate both types. The critical difference between them is in the materials used: in the eddy-current clutch, a soft-iron or special mild-steel rotor is substituted for the high-hysteresis member, and its magnetic segments are interconnected to induce eddy currents and inhibit hysteresis. As the clutch slips, torque is developed by the dissipation of eddy currents through the electrical resistance of the rotor ring. Increasing the rate of slip with constant excitation applied to the field coil generates stronger eddy currents, and increases torque. Varying excitation, on the other hand, changes field strength, which, in turn, proportionately affects the torque developed. To maintain constant output speed, clutch excitation must be modulated constantly to match changing load demands.

Performance

The eddy-current clutch is unique in that it must slip to develop torque. The torque vs slip relationship of a typical fractional-hp drive using an eddy-current clutch is shown on p. 26. Note that torque increases as a function of slip and excitation current. Transmitted power is proportional to the product of torque and output speed. Lost power is proportional to the product of torque and slip speed–power which must therefore be dissipated as heat within the clutch. For this reason, most small units contain built-in fans for forced air cooling, and larger units are usually water-cooled.

Advantages

The torque output of eddy-current clutches can be regulated over a wide range simply by varying the excitation current. These clutches are particularly useful as variable-speed controls for constant-torque loads, when supplied with error signals from a coupled tachometer-generator feedback system. In such applications, they offer good inherent regulation, with a maximum speed variation of ±2% over load changes of 75%, and with ±2% stability over the entire speed range.

Operation is smooth and quiet. Since there is no mechanical coupling, shock loading is virtually impossible. Torsional damping qualities are excellent.

Limitations

As with the other types, torque stability can be upset by temperatures high enough to affect coil resistance. The problem is complicated here by two important considerations:

- Eddy-current clutches run even hotter than the other types
- Unlike the other types, they are inherently speed-sensitive.

For REPRINT of above article, just check 628 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: This article completes a series which was started eight months ago for the purpose of presenting a complete, up-to-date survey of the clutch field. Because it was impractical to comprehensively cover the subject in one article, we divided the field into two segments—instrument and power clutches—and covered it in four articles. One additional article is being contemplated because this experience suggests that an article on standards and standard definitions is in order.

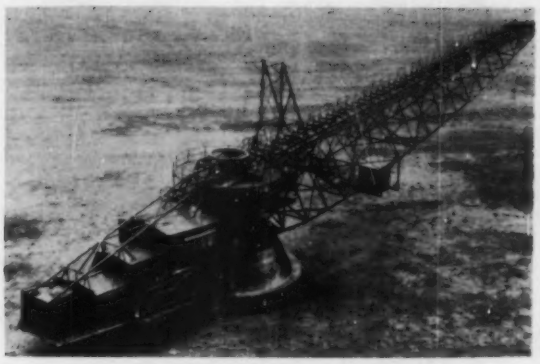
The other three articles are:

Selecting Clutches for Mechanical Drives, June 19 '61, p 43—Tells how to analyze the power train starting with the load requirement. Then a three-step procedure helps you pinpoint the type, location, and size of the clutch you want.

How to Select Electromagnetic Clutches and Brakes for Automatic Control, Dec 19 '60, p 29—Gives design information on the three major types—with sketches of 10 designs and 12 applications—to help you make the right choice.

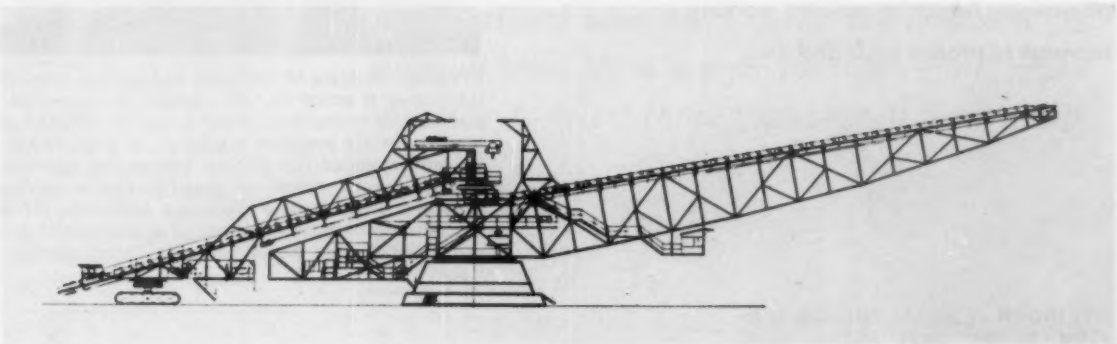
Realistic Ways to Speed Response of Dc Clutches and Brakes, Jan 23 '61, p 41—Analyzes response time in three logical steps: What is response time? What speeds are practical? How will standard units give you extra speed?

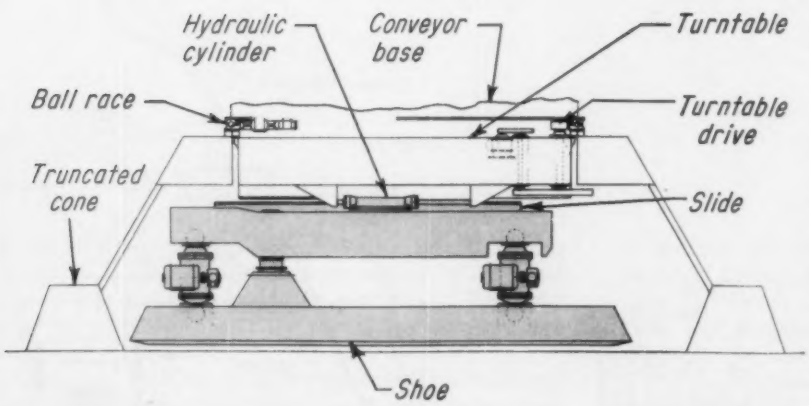
Frank Hall



Walking conveyor stays level

Keeping one foot on the ground at all times prevents jumbo-sized conveyor from tilting. Smooth steps permit operation during movement.





STRIP MINER consists of two overlapping conveyors supported on the walking undercarriage and caterpillar treads. The outer end of the first conveyor is supported by caterpillar treads and the inner end pivots on the centerline of the walking base. The second conveyor is entirely supported on a cantilevered jib counterbalanced by the electric power control room, transformer and workshops. Among the instrumentation included is an anemometer which stops all operations if a predetermined wind velocity is exceeded.

WALKING UNDERCARRIAGE consists of a truncated cone with a circular shoe inside it. The cone encloses the moving shoe and provides a base for the ball race on which the entire conveyor rotates.

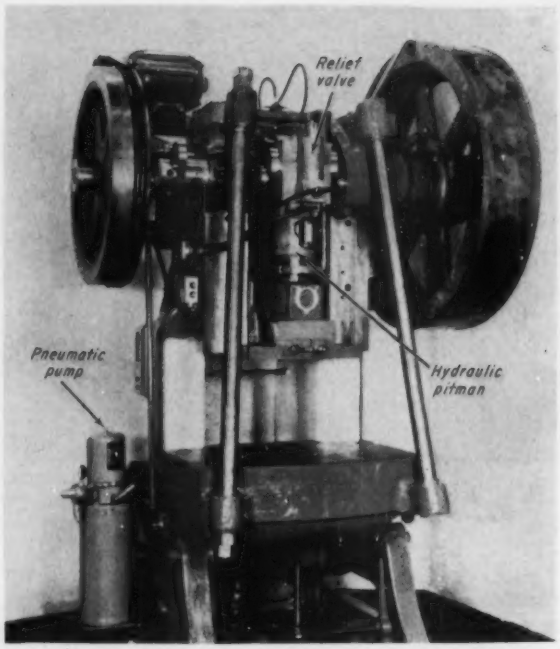
When walking, the shoe is lifted by motor driven jacks and advanced in the direction of travel. The shoe is then lowered until the cone clears the ground and the unit, now supported by the shoe, moves in the direction of travel. Shoe and turntable are linked by a ball-bearing slide which supports the conveyor during travel. Hydraulic cylinders move the shoe and the turntable horizontally on the slide.

Turntable and shoe are rotated by the turntable drive to point the conveyor in the required direction. The maximum step length is 3.28 ft and peak walking speed is 230 ft/hr.

PS . . . Strip-mining unit moves rock at a rate of 53,000 cu ft/hr with a belt speed of 15 fps. The 528-ton unit exerts a ground pressure of 9.95 psi when moving and 4.98 psi when stationary. Continuously operating conveyor is electrically powered from a 6000-v source. The two belts transport material a total of 312 ft to an elevation of 60 ft. The ZP-1500 strip mining conveyor was produced by VZKG Works, Ostrava, Czechoslovakia.

Pneumatic fuse protects press

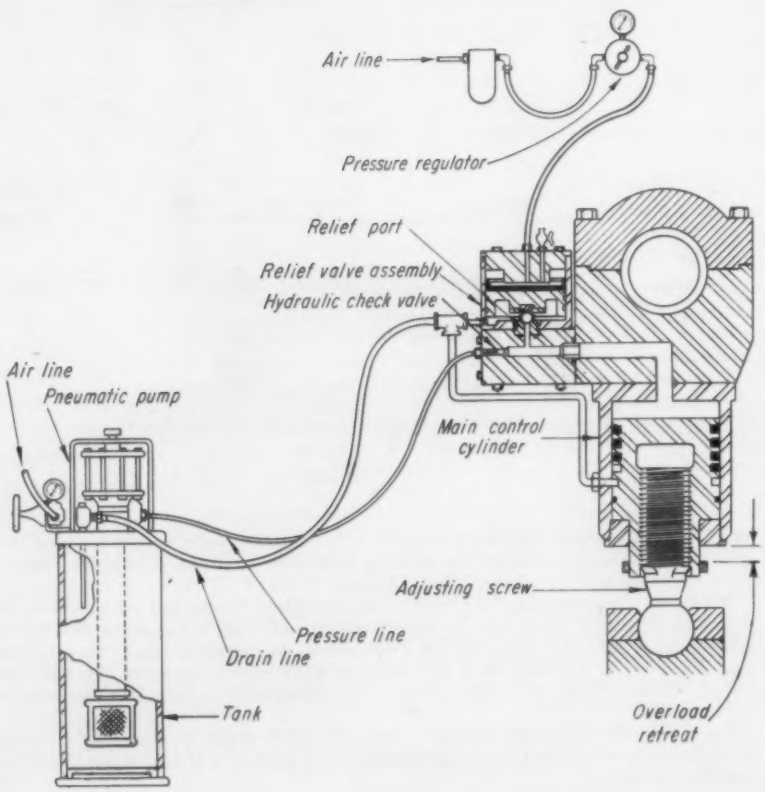
Hydraulic-pneumatic circuit breaker prevents press damages when overload occurs. Hydraulic pitman can be set for reduced working tonnage to protect tools and dies.



PITMAN consists of cylinder and piston assembly which telescopes if press or tool capacity is exceeded. Desired overload or retreating pressure can be adjusted directly in tons at the air pressure regulator. A limit switch actuated by movement of the pitman piston can operate a signal system, power cutoff or positive clutch control. When pressure is adjusted to produce a deliberate retreat during each stroke it enables the use of a mechanical press where a hydraulic press would normally be required.

CYLINDER of pitman assembly is located in the upper section which clamps around the crankshaft throw. The piston in the lower part is threaded to accept an adjusting screw. Air drives the hydraulic pump and also pressurizes the piston of the relief-valve assembly. High-pressure oil holds the main control cylinder fully extended. The desired retreating tonnage is set on the relief-valve air-pressure regulator. The pressure regulator is calibrated in tons.

When press force exceeds the desired tonnage, pressure rises in the main control cylinder and the relief-port ball is forced off its seat. Oil is ported to the tank. Escaping oil permits the piston and adjusting screw to retreat, protecting the press.



PS . . . Hydraulic overload pitman can be used to replace standard units on most conventional punch presses. The four models available provide a max capacity range from 47 to 165 tons. The pitman is produced by Dayton Rogers Mfg Co, Minneapolis, Minn.

how to select DRAFTING PAPER

New materials and steady improvement in conventional ones have made the choice a difficult one. Here is a comparison of all types and how to select those that best fit your needs.

JOHN J PAGE, *president*
Ogilvie Press, Inc.
Brooklyn, NY

ABOUT OGILVIE PRESS, INC.

The author's company specializes in preparing printed drafting materials of all kinds for architects and engineers. Ogilvie has developed a number of special inks for printing on drafting paper and is the originator of the nonreproducible cross-section grid. Today the company serves over 20,000 customers here and abroad with products ranging from sketch pads to precision grids for printed circuits.

■ Why is it important to choose the right kind of drafting paper? Let's ask the question another way: What would it cost to redraw every drawing in your files? Thousands? Millions, probably. That's the price riding on your decision.

Not many years ago, a large electronics firm discovered that the vellum they had chosen five years before was literally falling apart in the files. They paid the price. Or what about the small manufacturer who found the drawing film he was using was not satisfactory for the microfilming required by his government contracts. He paid it too.

Careless or (what amounts to the same thing) uninformed decisions were responsible for similar catastrophies: paper that discolored with age to the point that it could no longer yield a satisfactory print; film with a surface coating that flaked off after only a few months.

The hazard in choosing the wrong paper is clearly a two-sided affair. First there is the risk of getting a poor quality material. Second, there is the risk of selecting the wrong material for your needs. In either case, the answer is to know what is available and what properties to look for.

Ideally, the material should be strong, durable, transparent (for reproducibility), inexpensive, stable (no change in dimension with change in temperature and humidity), resistant to aging, and suitable for pen, pencil, typing, chart tape and microfilming. But you can't have them all. To get maximum transparency with paper you must sacrifice strength and durability. With film, you can get all three but the cost is high. And the cost is even higher if you demand extreme stability.

Available drafting room materials fall into four categories. From most expensive to least expensive they are: polyester film, cloth, vellum, paper. Many firms use some of each. According to a recent survey, vellum tops the list

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in popularity, with polyester film following closely behind. All have a place in the modern drafting room.

Vellum

Still the most popular and the least expensive of the general-purpose drafting materials, it serves most noncritical drafting needs. Basically, vellum is a rag paper treated for more transparency and better durability. Two types of transparentizers are in use today. Though the purpose of both is the same, each gives the paper slightly different characteristics.

Mobile transparentizers are similar to the mineral oil used to make some of the first translucent drafting materials. Today, mobile transparentizers are a synthetic oil or plasticizer. Its chief undesirable characteristic is its impermanence: it dissipates slightly with time causing a reduction in transparency after a few years. But this "mobility" also offers an advantage: the transparentizer will diffuse through the paper to fill marks caused by creases or heavy erasing. In general, papers treated with a mobile transparentizer have less initial transparency. The once-common problem of staining or "leaking" has been solved for the most part.

Solid transparentizers, by contrast, are permanently impregnated into the paper and suffer little from aging effects. The inert resins used in their manufacture provide a high level of initial transparency but because they stay put once they are in the paper, folds and cracks caused by rough handling will show as ghost marks in prints made from the drawings.

Of the two, solid transparentized vellums are slightly more popular, probably because of their better aging resistance. They are also somewhat more expensive.

The other characteristics of vellums–strength, erasing qualities, stability, pencil and ink "take"–depend largely on the quality of the paper base material. These can vary considerably from one stock to another. Vellum is supplied in a range of weights varying from 10 to 24 lb (weight of 500, 17 x 22 in. sheets). For ordinary drafting purposes, a weight between 16 and 20 lb has sufficient durability without sacrificing transparency.

The Trend: Because of its low cost, and with steady improvement in manufacturing methods, the solid transparentized vellum will continue to hold its position as the preferred, all-purpose drafting medium for the next few years. However, a cost reduction in competitive materials may change the picture.

Polyester film

This is the newest and undoubtedly the finest all-purpose drafting material available today. In little more than five years it has captured a large portion of the market and now threatens to replace conventional materials in many drafting rooms.

Polyester film is made by bonding a mat surface to one or both sides of a clear Mylar sheet. (Actually, the sheet must be coated on both sides to prevent curling, whether the coating has a mat surface or not.) If the coating is applied by one of the many processors (called "converters") the product is known generically as Mylar film and specifi-

text continued on page 34

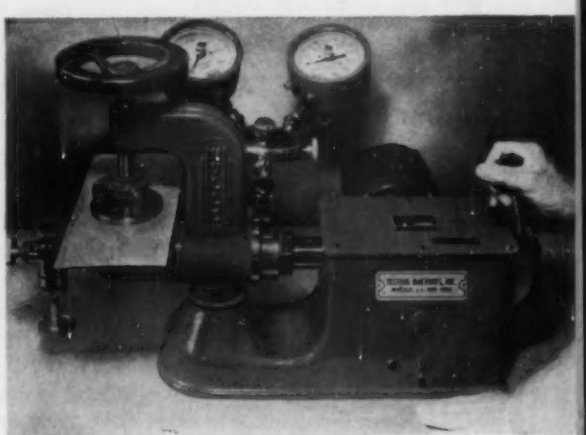
THESE STANDARD LABORATORY

You can't make these tests yourself—the testing machines are too specialized and too expensive. But before buying a drafting material you should know where it stands on each of these measures of quality. Testing laboratories and paper manufacturers use these tests for quality control, for comparing competitive products and to determine whether the material meets federal specifications.

The eight tests below are chiefly designed for paper and vellum. Some of them are also used for film and cloth, but in the case of these materials, there are additional tests that give a measure of quality. With film, for example, there are tests for stability and clarity. And for cloth, tests emphasize such properties as thread count and moisture resistance.

Basic weight is measured by weighing ten sheets of paper, 1 ft sq. This figure is then extrapolated to give the weight in terms of 500 sheets, 17 x 22 in. Usual weights range from 8 to 16 lbs, for paper and from 10 to 24 lbs for vellum.

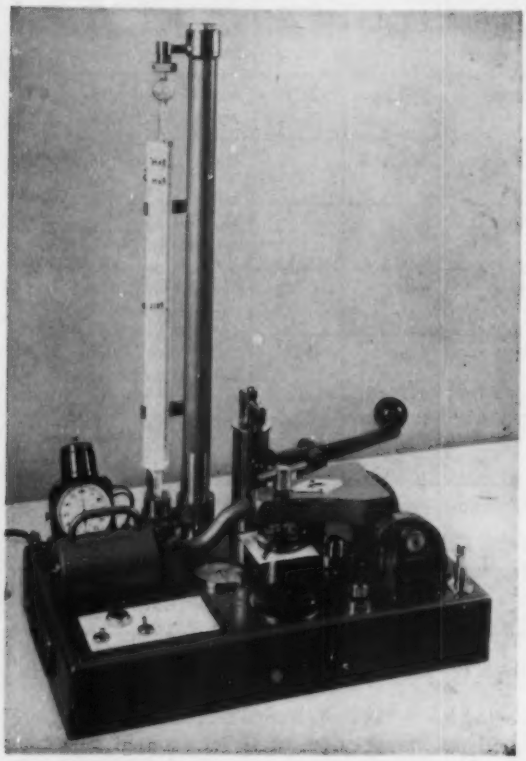
Thickness is average thickness of ten sheets individually measured by micrometer (max and min readings are also given). Thickness of natural bond paper in the usual weights varies from 0.0015 to 0.003 and vellum ranges from 0.002 to 0.004.



Bursting strength is measured by the Mullen tester shown above. The sample is pressed over a fixed opening in the end of a pipe as shown at left, and bursting pressure in psi is read from the pressure gages (with telltale hand that records max pressure). The usual procedure is to make ten tests with ten sheets and record max, min and average bursting strength. For a 13-lb 100%-rag paper, a typical reading is 30 lbs; 35 lbs would be a very good reading. A vellum of the same weight would give about the same readings.

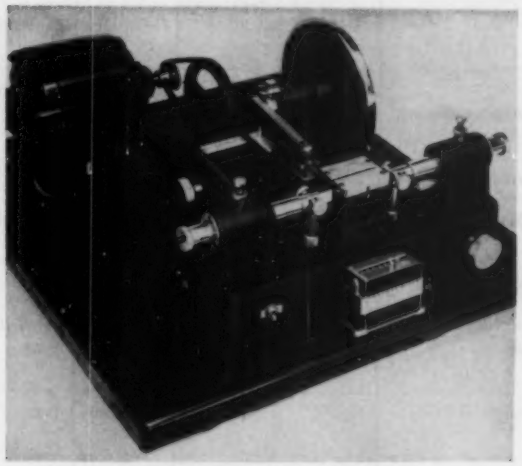
Resistance to tearing is measured by an Elmendorf

tester. A standard size sample is held between a fixed clamp and a movable clamp and the tensile strength measured in grams. Ten tests are made: five in one principal direction and five in the other. Max, min and average readings are recorded. Typical reading for an average paper or vellum is 25 gms; for a good paper or vellum: 40 gms.



Surface smoothness is measured by the Bekk tester above. The sample is pressed against a polished metal surface with a calibrated force and air pressure applied to the joint. The instrument measures the time required for 10 cc of air to leak past the joint formed by the surface of the paper and the metal surface. Five tests are made on each side of the sheet. For a reasonably rough surface, the time would be about 10 sec; for a smooth surface, about 40 sec.

Dimensional Stability, as affected by humidity, is determined by the TMI Expansion and Shrinkage tester (formerly known as Schopper Expansimeter). A standard size sample is stretched with a fixed force between two clamps, one of which is movable. A dial indicator measures change in length when relative humidity is changed from 65% to 50%. Five samples are tested in the two principal directions. Typical reading for paper or vellum with average stability is 0.20%; with extreme stability: 0.13%.



Folding endurance is determined by the Schopper tester above. The sample is clamped between two spring-loaded spindles and passes through a slotted block carrying a slotted oscillating plate. The block is equipped with rollers where the paper passes over its edges. The fold (actually two 90° bends) occurs at the edges of the oscillating plate. The counter on the front of the machine records the number of double folds (back and forth) the paper will withstand before it separates at the fold. As before, results are in terms of max, min and average number of folds of five samples measured in the two principal directions. Usually, the material is tested again after aging for 72 hours at 100 C. Typical reading before aging: 1800 double folds; after aging: 1100 double folds.

Opacity (or transparency) is usually measured by a Bausch & Lomb Opacimeter or a Photovolt Reflection Meter. In either case, the test is made by placing the sample between an ordinary incandescent light source and a reflecting background. The meter measures the difference between light reflected from a black background and that reflected from a white background. This difference is recorded in percent with 100% being perfectly opaque and 0% being perfectly transparent. Usual procedure is to make five readings before aging and five readings after 72 hours at 100 C. Max, min and average readings are given along with average increase in opacity after aging. Typical reading before aging: 41.5%; after aging: 46%.

Though these mechanical tests are valuable, the true test of a drafting material is its performance on the drawing board. That is the only place to test such qualities as erasability, pencil and ink "take", reproducibility. At the moment, there is no way to make a quantitative measurement of these all-important properties.

COMPARE THESE COMMON MATERIALS

	Strength	Reproducibility	Flexibility	Stability	Erasibility	Aging	Approx. Cost $/yd.^{2}	Comments
Vellum (solid transparentizer)	Fair	Good	Excellent	Poor	Fair	Good	0.40	Most popular general-purpose material
Vellum (mobile transparentizer)	Fair	Fair	Excellent	Poor	Fair	Good	0.35	Popular general-purpose
Polyester film	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	2.00	Best all-around drafting material
Tracing Cloth (pencil)	Good	Good	Excellent	Poor	Good	Excellent	2.00	Moisture resistant, accepts ink poorly
Tracing Cloth (ink)	Good	Good	Excellent	Poor	Good	Excellent	1.60	For permanent drawings
Paper (all rag)	Fair	Fair	Excellent	Poor	Fair	Good	0.20	For drawings requiring few copies
Paper (part rag)	Poor	Fair	Excellent	Poor	Poor	Fair	0.12	Chiefly for sketches and preliminary drawings
Paper (all sulfite)	Poor	Good	Excellent	Poor	Poor	Poor	0.07	Chiefly for sketches and preliminary drawings
Glass cloth	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	9.00	Little used, replaced by stable base polyester film
Vinyl film	Good	Excellent	Fair	Excellent	Excellent	Excellent	1.50	Little used, except for scribe-coated stock
Acetate film	Fair	Excellent	Excellent	Good	Excellent	Excellent	1.00	Little used, except for overlays

cally by the converter's trade name. On the other hand, precoated film is available directly from the Mylar film manufacturer (DuPont) and is known by the trade name Cronaflex. The only difference between Cronaflex and the Mylar films is the coating process. However, it has been our experience that Cronaflex is a somewhat superior product, being less subject to manufacturing variations.

Polyester films have many attractive qualities. First, they are easily the most durable materials ever provided for the drafting room. They cannot be torn, bent or cracked—they are virtually indestructible. Transparency is unexcelled; pencil lines reproduce sharp and clear and second originals made from pencil drawings have an almost ink-like quality. Because of their transparency, you can make prints faster than with any other drafting media.

Draftsmen who work on the polyester film find that they do not need to use a soft pencil to get a dense, heavy line. The harder pencils give sharp, clean lines without danger of smudging. Also, special pencils are now available, that give strong reproducible lines without smudging.

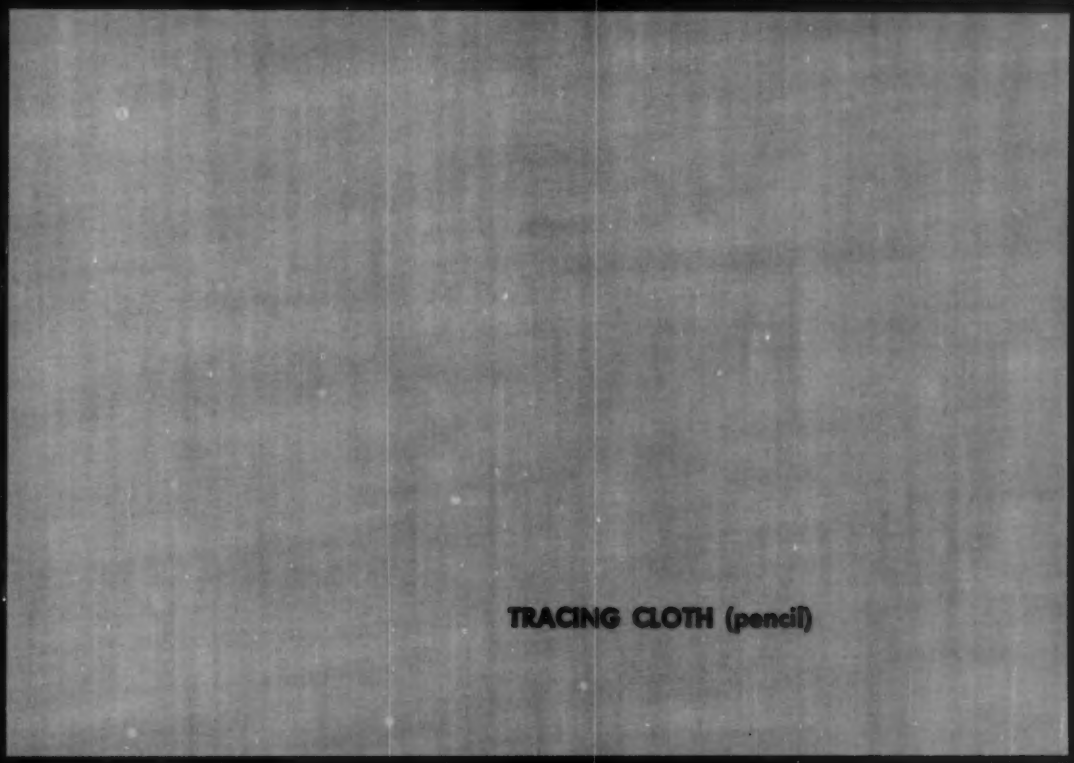
When working with ink, be sure the surface is clean and free of oil that may come from handling. (To remove oil, use an eraser or a dry cleaning pad.) A high-viscosity, quick-drying ink works best. Pencil and ink lines are easily erased without leaving ghost marks. Use an electric eraser sparingly. It is not needed for most erasures and there is danger of overheating and warping the base material.

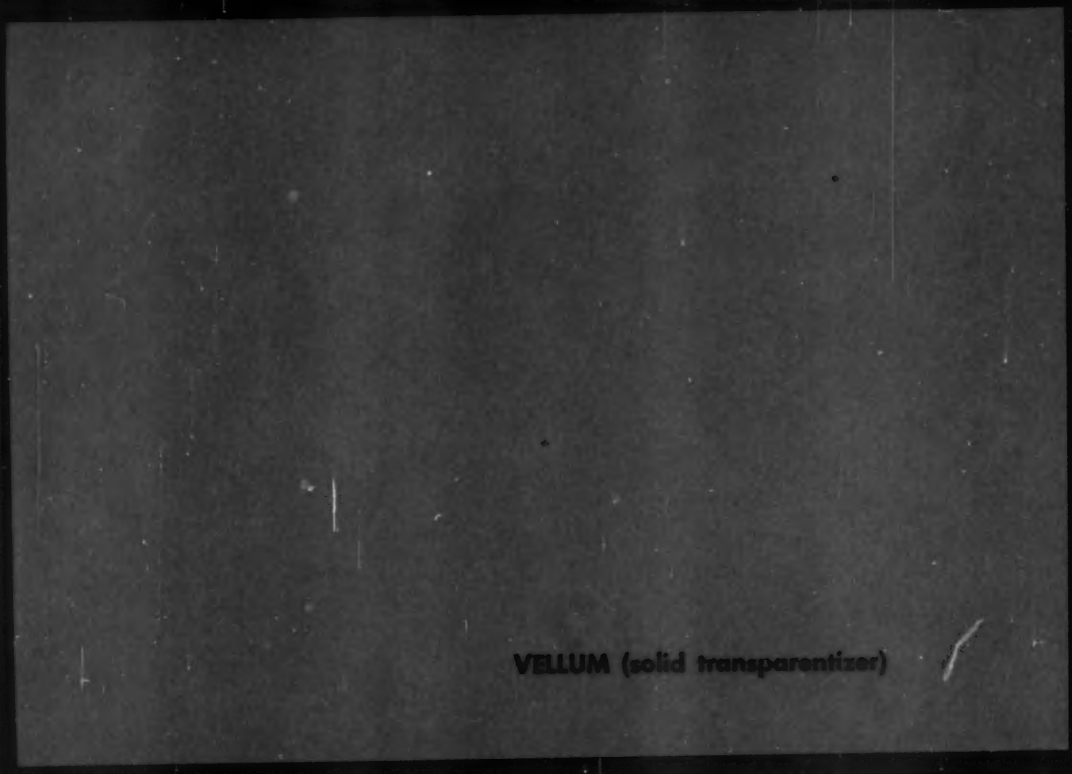
Resistance to aging is another area where these films score well. Stored for a long period of time, they will show only slight discoloration, or loss of flexibility and transparency. This characteristic, however, varies to some extent with the converters of Mylar film.

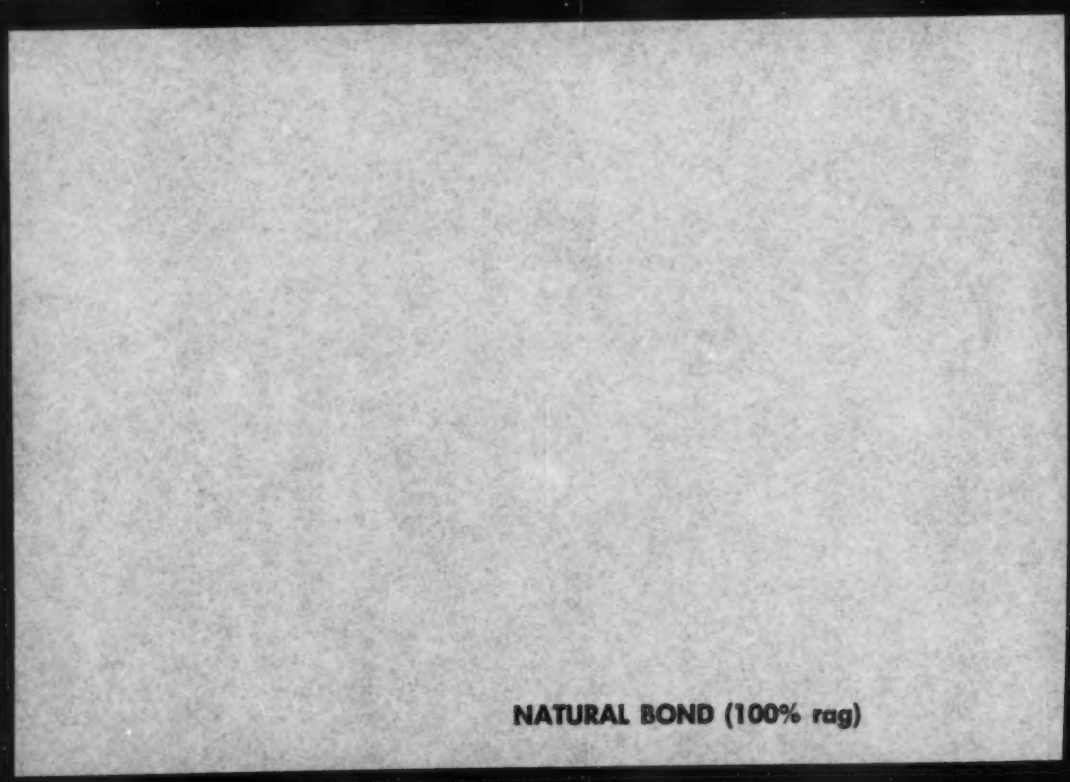
Polyester film is supplied in six thicknesses: 0.002, 0.003, 0.004, 0.005, 0.007, 0.0075 in. (This is the thickness of the base material; after coating it is 0.0005 to 0.0015 in. thicker.) For general-purpose drafting, the 0.002, 0.003 or 0.004 film is adequate. The heavier materials (0.005, 0.007 and 0.0075) are called "stable base" materials and are used where extreme dimensional stability is required (templets and printed circuits, for example). Its inch-per-inch stability in all directions is on the order of 0.15×10^{-4} per deg F or per 1% change in relative humidity.

The Trend: Where emphasis is on superior performance, polyester film is the growing choice. At its present price, it is a fair competitor for cloth and is even replacing vellum in some applications.

POLYESTER FILM (.004)


TRACING CLOTH (pencil)


VELLUM (solid transparentizer)


NATURAL BOND (100% rag)

TESTS YOU CAN MAKE

Here are some simple checks to help you judge the quality of a drafting material before you buy.

- Drop a sheet on a flat surface. A good stock should lie flat with little tendency to curl or warp.
- Hold a sheet so that the light reflects from the surface. A well-made sheet will show no streaks, stains, or other irregularities.
- Draw a line and erase it several times. Notice how well it erases. Look for abrasion of the surface. On film, watch for a tendency to cut through the laminated coating. Make a copy of the erased line on your reproduction machine and inspect it for ghosts.
- Crease a corner several times back and forth and notice how well it recovers. Does the crease leave a line that will show up in reproduction? Does the material crack? Is it easier to tear along the crease?
- Rub the surface with a moistened finger or cloth. If the material is water resistant, there should be no mark and no warpage.
- Tape a large sheet to a stable surface—a sheet of metal or an aluminum drafting board, for example. Allow it to stand at a constant temperature for several days. Look for wrinkles or bumps that are a sign of poor moisture stability.
- For film, scrape a sharp instrument (your fingernail will do) across the surface and look for a mark. Film with a tough coating should show little or no mark.
- For cloth, press a piece of pressure-sensitive cellophane tape over a dry, inked line. Now pull it off and look for a mark on the tape. A cloth with good ink adhesion should show little or no ink pick-up.

Cloth

Until the introduction of the polyester films, cloth was the best material for permanent drawings. Because it is a coated linen, it is stronger and more resistant to aging than paper. Many companies still rely on cloth because they feel it gives sharper microfilm images than polyester film when photographed with reflected light (the usual method). However, microfilm specialists claim that film can be photographed with transmitted light to give equally good results. Though some draftsmen still prefer to work on cloth rather than film, it is our feeling that the demand for cloth will diminish as more draftsmen discover (and become accustomed to) the advantages of polyester films.

Like film, cloth is available with a toothed surface on one or both sides. Most of the cloth sold, however, has a working surface on one side and a glazed surface on the other. White is the more common color but blue tracing cloth is also available. Surface coatings come in three different grades: pencil surface moisture-resistant pencil surface and ink surface.

Moisture-resistant cloth is best for most drafting-room work because water and perspiration drops will not mark or distort the material in a way that shows up in reproduction. In fact, it can be immersed in water for several hours without damage. But it has a disadvantage: ink, being a water-base liquid, does not adhere well to the surface. Some manufacturers make moisture-resistant cloth claiming that it is suitable for either ink or pencil. However, inked lines flake off more easily than they do on plain cloth. Moreover, drawing time is greater and results uncertain.

Plain cloth, surfaced for either pencil or ink, is somewhat less expensive than the moisture-resistant variety. But it must be handled more carefully to avoid water spotting. Pencil-surfaced cloth has a noticeably rough surface ("tooth") for better pencil take; ink-surfaced cloth has a less pronounced tooth but it is more resistant to the abuse of heavy erasing. A good quality ink cloth will withstand several erasure–re-inking cycles without the ink spreading or "feathering".

The Trend: In most drafting rooms, cloth is being slowly replaced by film except for those situations where it is felt that cloth gives better microfilming results. Of the drafting rooms still specifying cloth, most prefer pencil drawings on moisture-resistant cloth. These withstand extensive handling and reproduce nearly as well as ink drawings.

Paper

Despite the development of newer and better materials, there is still a place for natural bond tracing paper in many drafting rooms. The reason: it's inexpensive and adequate for many jobs where durability and transparency are not of primary importance.

Natural bond papers are manufactured in various compositions, from 100% rag, to mixtures of rag and sulfite, to 100% sulfite. Sulfite is made from wood, chemically reduced to fibers (wood can also be reduced to fibers by grinding, but the resulting paper is of poor quality, unsuitable for the drafting room); rag paper is made from cotton fibers. There is a wide variation in quality, even among papers of the same composition. The over-all quality of a 100%-rag paper, for example, can range from very good to fair, depending on the type of rag and the technique of manufacture.

In the drafting room, the only suitable natural bond papers are the all-rag varieties; the part-sulfite and all-sulfite papers should be restricted to sketches, note paper, computations and one-shot free-hand drawings. Compared to the sulfite papers, the 100%-rag stocks are little affected by aging and have excellent strength. They are suitable for work with pencil, ink or typewriter and can be erased without ghosting and with little damage to the surface.

On the other hand, sulfite paper, with its shorter fibers,

is more transparent and permits faster reproduction. Sulfite paper, in fact, can be made even more transparent than the most transparent vellum. But the short fibers seriously limit the strength, the most transparent being too fragile for any kind of drafting work. And the chemicals used in their manufacture cause yellowing and deterioration of strength after a relatively short time.

Because of its low cost, untreated rag paper should be specified for tracings, sketches and drawings that do not require a large number of prints. It ages as well as vellum and is entirely satisfactory for drawings that will become a part of the permanent file. For these reasons, it is often the preferred medium for research and development shops where only one or two sets of prints are needed and there is only infrequent reference to the original. It is manufactured in weights from 6 to 16 lb, the 10- to 14-lb stocks being the most common choice.

The Trend: Not much change expected in the next few years. Where 100% rag stock is adequate for the job, it is the least expensive choice.

Special materials

Though the four materials described above should meet almost every drafting need, there remain a few special materials found in some drafting rooms. Some are all but obsolete; others, though less popular now than they once were, still have some market because of certain limited applications.

Glass cloth, for example, was once the unanimous choice for templet drawings and other drafting work requiring a dimensionally stable drawing surface. It changes little with changes in temperature and humidity, and is transparent enough to allow sharp, fast reproductions. But because of other undesirable characteristics, it has been almost entirely replaced by the heavier, stable base, polyester films.

First, it is expensive—almost three times the cost of the best polyester films. Moreover, the glass fibers are easily damaged: edges fray and crumble if not properly taped or bound and surface fibers can be broken with sharp drawing instruments. If it is surfaced with an opaque scribe coat, as is commonly the case in making templets, the draftsman must be careful not to scribe deeper than the thickness of the coating. Broken fibers seriously reduce the transparency and affect reproduction qualities. Glass cloth is still used to some extent in the aircraft industry but this market is diminishing. Many drafting supply houses have now removed it from their catalogs.

The polyester films have also nearly eliminated the once-popular **vinyl** and **acetate** films. Vinyl stock, coated in the same way as the polyester films, was originally intended as an all-purpose drafting medium. However, in the case of vinyl, the mat surface does not adhere well, and the base material is weak and becomes brittle with age. Vinyl is still used as the base for scribe-coated stock because it is less easily scratched or cut with the scriber than the polyester-base materials.

Acetate film was also used as a general-purpose material to some extent but it, too, has poor aging qualities and very low tear strength. It is used today almost exclusively for overlays and other applications where the need for extreme transparency outweighs its less desirable properties.

When buying, remember that . . .

Transparency can't be judged by looks alone. Even though a material looks transparent to you, it may be blocking certain frequencies of light. Transparency to the ultraviolet light in your reproducing machine is what you're after. A paper with a yellow cast may print faster than a more transparent-appearing paper with a blue cast.

Adhesive symbols and special chart tapes work best on the Mylar films. Because these tapes are normally used for printed circuits and other applications where dimensional stability is important, the heavier films (0.005, 0.007 and 0.0075) are recommended. Tapes can also be used on vellum but work best on those with a solid transparentizer because the adhesive absorbs a mobile transparentizer.

Drawings for the military must be put on a material that meets the federal specifications. Find out what the requirements are before you buy. Also, title blocks and format must conform to military specifications.

Preprinted title blocks, borders, tolerance blocks, change blocks and other information save drafting time and are economical for even the smallest drafting rooms. Printed copies can be made up by a drafting supply house or by a printer who specializes in printing drafting paper. Consider preprinting other information such as standard abbreviations, or even parts of the drawing itself if it is a standard device with a large number of variations. Pale-blue nonreproducing lines can also be preprinted. These may be in the form of grid lines, parts of drawings or proprietary information that you do not want to appear on prints sent to subcontractors. Lines of various colors can be used to make lines of varying prominence on prints. Or black lines can be screened to make them less prominent.

Choose pencils, erasers and inks to match the peculiarities of the drafting material. For the best combination, find out what the manufacturer recommends, or run a few experiments with several different types. Because these supplies are inexpensive, experiments are cheap compared to the possible saving. A good pencil will give a sharp dense line without smudging and without need for frequent resharpening. And the right eraser should remove marks with little effort and a minimum of surface abrasion.

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EDITOR'S NOTE: For more about drafting materials, equipment and methods see:

Latest Technique in Camera-made Drawings, Sept 5 '60, p 58—Two important improvements in the photodrawing method and two case histories.

13 Ways to Cut Drafting Costs, Sept 28 '59, p 28—A check list of modern drafting room methods and a guide to manufacturers of time-saving drafting equipment.

Microfilm Pushes Drawings Aside, Oct 27 '58, p 44—What microfilm can do to save space, money and engineering time.

For Today's Draftsman, These Modern Tools, Oct 13 '58, p 68—A look at what's new in drafting boards, drafting machines, reproduction equipment.

—Charles J. Lynch

Madison-Kipp zinc and aluminum die castings

Impellers for a ventilator pump must be held to extremely close tolerances.

Madison-Kipp showed the way to produce these parts with a bare minimum of secondary operations.

If it is an intricate shape, a question of close tolerance, a problem of casting-in inserts or just a dependable source for quality castings in quantity, the engineering skill, die making experience and years of manufacturing background of Madison-Kipp are available to you.

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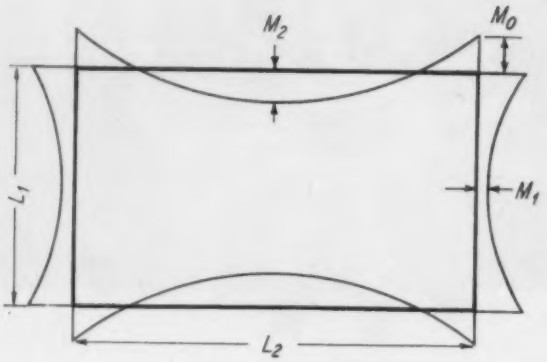
CIRCLE 45 ON READER SERVICE CARD 45

For rectangular frames under uniform loads

No three-moment equations needed instead, design curves find the three key bending moments.

I. BALSYS, *design consultant, Don Mills, Ont*



SYMBOLS

$I_{1,2}$	= Moment of inertia of short side of frame and long side of frame respectively, in.^{4}
L_1	= Length of short side of frame, in.
L_2	= Length of long side of frame, in.
M	= Moment multiplier, in.-lb
$M_{0,1,2}$	= Bending moment at corner, midspan of short side and midspan of long side, respectively, in.-lb
W	= Uniform load, lb/in.
$\alpha_{0,1,2}$	= Bending moment coefficients
β	= Load direction factor

■ Rectangular frames reinforce ducting, bins, tanks, airlocks and test chambers. In each of these cases air pressure, water pressure or possibly grain or gravel pressure exerts a uniform load on the frame. Starting from scratch to solve for bending moments one must apply the three-moment equation. At the first stage of simplification one can use equations worked out for each different kind of loading ("7 Moment Formulas for Rectangular Frames," Nov 23 '59, p 94). Here is a second stage of simplification, curves for the single case of uniform loading.

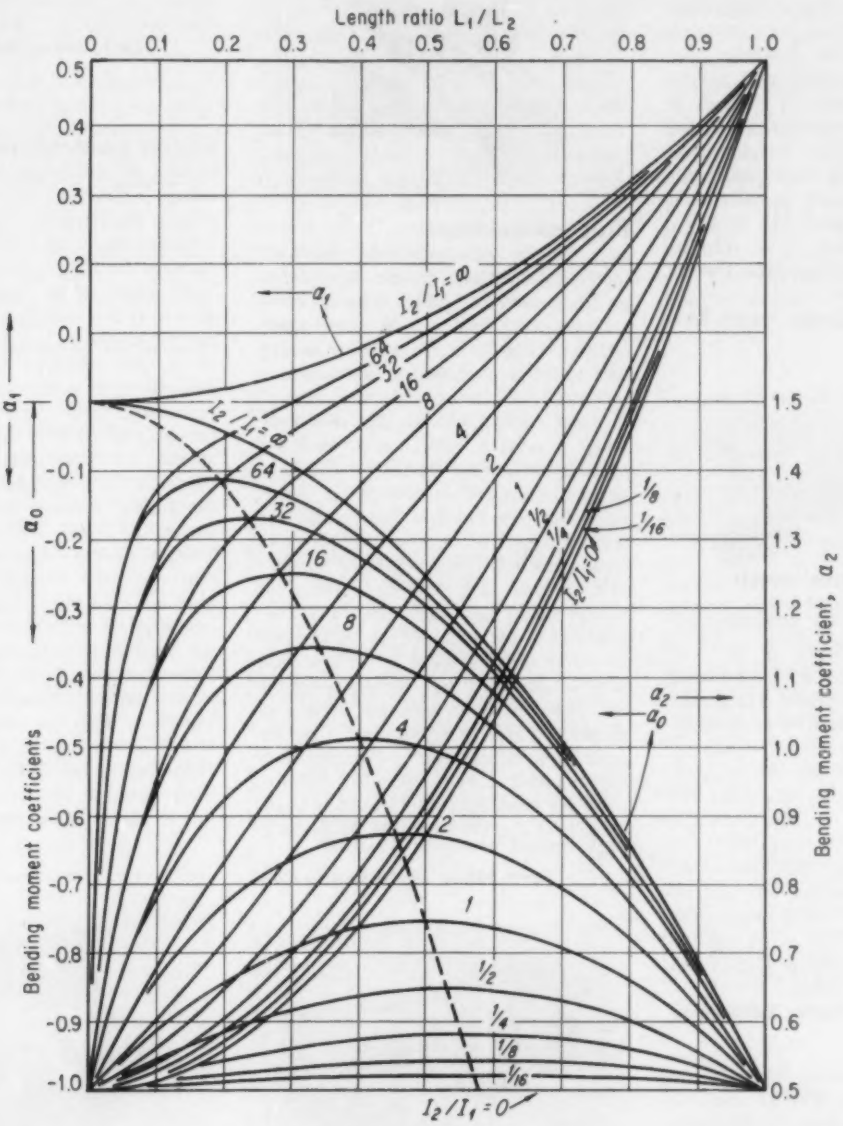
Equations find bending moment at three important positions.

At the corners $M_0 = \alpha_0 \beta M$

At the middle of the short side $M_1 = \alpha_1 \beta M$

At the middle of the long side $M_2 = \alpha_2 \beta M$

For external pressure $\beta = +1$; for internal pressure $\beta = -1$. Moment multiplier $M = WL_2^2/12$, and $\alpha_{0,1,2}$ are located on the curve with the ratios L_1/L_2 and I_2/I_1. A positive answer means that the inner surface of the frame is under tension at that point.



EXAMPLE: Agriculture labs grow plants at simulated altitudes in a small vacuum chamber 20 in. high by 30 in. wide. As a result of the spacing each reinforcing frame carries a uniform load of 70 lb/in. when pressure inside the tank is lowest. All parts of the frames are made of the same size I-section. What are the bending moments at the corners and at the midspans?

Solution: Since the cross-section of the frame doesn't vary, $I_1/I_2 = 1.0$. Pressure is from the outside, so $\beta = -1$. Length ratio $L_1/L_2 = 20/30 = 0.67$. With this information, go to the curves and find $a_0 = -0.78$, $a_1 = -0.11$, and $a_2 = 0.72$.

Only one more bit of information is necessary before calculating the moments; that is moment multiplier $M = WL_2^2/12 = (70 \times 30^2)/12 = 31.5 \times 10^2$. Then the moments are:

$M_0 = a_0\beta M = 1 \times 31.5 \times 10^3 (-0.78) = -24.6 \times 10^3$ in.-lb

$M_1 = a_1\beta M = 1 \times 31.5 \times 10^3 (-0.11) = -3.46 \times 10^3$ in.-lb

$M_2 = a_2\beta M = 1 \times 31.5 \times 10^3 \times 0.72 = 22.7 \times 10^3$ in.-lb

Rotary limit switches . . .

are low-ratio, geared-down and geared-up units with gear coupled potentiometers as optional equipment. Among applications is controlling end limits of motor-operated valve with potentiometer providing continuous valve position indication at remote location. Available with 2 through 4 SPDT or 2 DPDT switches with gear ratios of 1:1, 1:2, 1:3, 3:1 and 2:1. Potentiometer couplings are available with 1:1 ratio units and can be geared at 1:1, 1:2 and 1:3. Priced from $37 to $207, with delivery in approx 6 wk. **Gemco Electric Co, 25685 W Eight Mile, Detroit 40.**

Circle 300 on Reader Service Card

Pushbutton release catch . . .

for quick release of lift-off covers, can be used with any metallic or plastic material with sheet thicknesses to $\frac{7}{8}$ in. The holddown is mounted on inside of cabinet with rivets, or it can be welded. To operate, button is pressed in and cover is lifted. Slams shut for automatic, positive latching. Measuring ¾ in. wide and 2½ in. long, the holddown is available with either 90° or 180° keeper mount. To install, a single hole for the button, plus three rivet holes (or two rivet holds and a weld) are made. Keeper and release button are cadium-plated steel. Spring is lubrite spring steel; welding nib (where used), copper-plated steel. From stock. **Southco Div, South Chester Corp, Lester, Penna.**

Circle 301 on Reader Service Card

Miniature power meter . . .

continuously measures shaft hp by means of radio-telemetry. Mounted directly on a shaft, it transmits readings to a remote location without wires, slip rings or other physical connections between rotating and other stationary equipment. Complete unit weighs only 3½ lb, compared with 2½ tons for conventional equipment. Hp readings are reported to be within 1%. Uses a miniature FM/FM transmitter for noise-free operation and complete, solid-state electronics for the radio-telemetry portion of the system. Electronically sensed torque-and-rpm signals are mixed and amplified. A 3-channel system also is available if separate and direct indication of torque and rpm is desired. **Unilectron Inc, 129 Binney St, Cambridge, Mass.**

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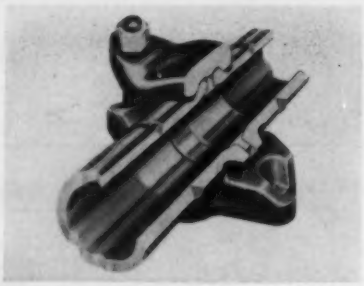

Pipe connections . . .

resist pressure and stress through use of all-metal seal ring with flexible tapered lips on either side of a rigid rib. Lips do actual sealing against mating hubs. Lips' angle of taper is slightly less than that of mating hub sealing surface, and as connection is tightened by clamps, hubs are brought together, causing seal ring lips to deflect. Ring is reusable, eliminating need for replacement gaskets. In tests, a 2-in. connection withstood 26,000 psi at which point the pipe failed; a 7-in. connection withstood 19,500 psi. Also, a 10¾-in. OD connection held under a bending moment of 2 million lb-ft. and no evidence of leakage could be found when a 2½-in. connection was subjected to an external tension load of 290,000 lb with a fluid pressure of 3600 psi. Sealing principle also allows a sharp reduction in over-all weight and size of connection. They are reported to be as much as ½ smaller than equally rated flanges. Standard connections are from stock in 1 to 30-in. sizes. **Gray Tool Co, PO Box 2291, Houston 1, Tex.**

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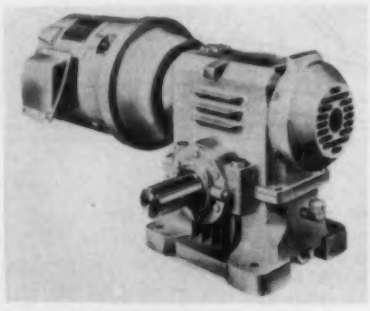

Motorized reducer . . .

incorporates an involute helicoid thread form, said to have the highest load capacity of any type worm gear. Gearing is generated to produce leaving-side contact, which reportedly provides the ideal condition of an entering-side gap for lubricant. Available in eight sizes for motors from 1 to 20 hp, with center distances from 2½ to 8 in. and speed ratios of 5:1 to 70:1 and higher. Either single or double-extended gear shafts are supplied. Motor is easily attached to or detached from a flange on the gear case. Motor and worm shafts are connected by couplings which require no lubrication. **De Laval-Holroyd Inc, 121 First Ave, Trenton 2, NJ.**

Circle 304 on Reader Service Card

Silicon photosensor . . .

handles up to 20 v of reverse breakdown voltage with under 10-microamp leakage current, reportedly making possible greater economies in design of photodiode readout circuitry for data processing equipment. With higher voltage capability than other devices in use, unit is adaptable to direct coupled circuitry. It is hermetically sealed in a glass envelope of 0.080-in. dia. Available types include one with active area positioned parallel to longitudinal axis of the diode to provide for side-reading and another with active area positioned perpendicular to longitudinal axis and a lens for frontal exposure to incident light, eliminating need for critical focusing. Though designed originally for punched card and tape readout systems, can be used in production flaw testing, signal switching, photographic sensing and sound pickup. Spectral response covers range from visible to near infrared radiation, from 5,000 to 11,000 A. Peak response is at 9,500 A. Sample quantities from stock at $5 to $12, depending upon specifications. **Philco Corp, Lansdale Div, Lansdale, Penna.**

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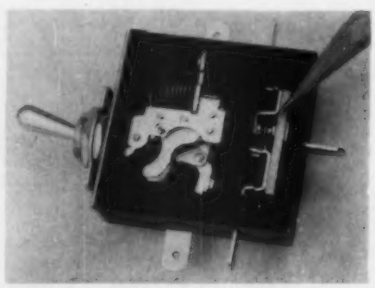

Circuit breaker . . .

has miniature snap-action contacts that can operate signal light or alarm. Contacts are enclosed within breaker case but are electrically isolated. They are actuated mechanically by breaker switching mechanism. Contact ratings are 5 amp, 125 v and 2.5 amp, 250 v ac, 60 c resistive; and 1 amp, 50 v dc resistive. Breaker, measuring 2½ x ⅝ x 3⅛ in. and weighing 1½ oz, also can double as an "on-off" toggle switch. Can be mounted in only ½-in. panel hole and has universal terminals which accept soldered, solderless or screw-type connections. Unit is magnetically actuated and

requires no temperature derating. Since its operation is non-thermal, its current rating and must-trip point are unaffected by high ambient temperatures. Choice of three overload responses permit breaker to be matched to application's load characteristics. Can be supplied with a fast or slow hydraulically controlled inverse time delay or with non-time-delay instantaneous response. On short circuits or overloads 500% the breaker's rating, tripping takes place instantly without time delay. Breaker's current rating is 120 v, 60 or 400 c ac, or 50 v dc. Can be supplied in any integral or fractional rating from 0.05 to 15 amp. **Heinemann Electric Co, 378 Magnetic Dr, Trenton 2, NJ.**

Circle 306 on Reader Service Card

Organic friction material . . .

is said to almost completely eliminate fading under high temperature conditions. Makes possible positive control of brakes and clutches at temperatures up to 1000 F under conditions of high load and fast cycling. Shows average coefficient of friction of 0.56 at 350 F; 0.62 at 600 F; and 0.53 at 1000 F. Rate of wear is said to be within acceptable limits for materials of high friction level. Material is rigid, tan in color and contains zinc particles. Available in blocks, facing and sheets. **Johns-Manville, 22 E 40th St, New York 16.**

Circle 307 on Reader Service Card

Thermoplastic resin . . .

reportedly can be controlled to an exacting degree in processing, producing uniform, high-quality parts. A fluorocarbon formed by the homopolymerization of chlorotrifluoroethylene (CTFE), the resin contains more than 60% fluorine by weight. Available in two grades (based upon molecular weight), varying in pelletized, unpelletized and plasticized forms. Said to offer thermal stability from —400 to 400 F; abrasion resistance; resistance to wide range of chemicals, fuels and corrosive media; top electrical properties; infrared transmission qualities; and zero moisture absorption. Also, and depending upon size or thickness of particular product requirements, a highly crystalline or highly amorphous condition can be induced by special heat treating techniques. **Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6, Minn.**

Circle 308 on Reader Service Card

High-strength adhesive . . .

is heat resistant and can be spray-applied in a relatively dry form. Requires only contact pressure for bonding a variety of materials, including: polystyrene, sheet plastic, steel, aluminum, wood, particle board and foamed glass. Applying adhesive in relatively dry form eliminates most of the solvent content and permits its application directly to polystyrene foam without causing deterioration. Also can be used in fabrication of honeycomb sandwich panels, since excellent filleting properties are reportedly obtained from spray technique. Component parts coated with adhesive can be assembled, positioned and repositioned if necessary without components adhering to each other. After proper assembly, a momentary application of pressure, as achieved with nip roll, immediately bonds the components. Adhesive maintains high-strength properties over service temperature range of —30 to 250 F. One gal. covers over 300 sq ft of bonding surface. **Adhesives, Coatings & Sealers Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6, Minn.**

Circle 309 on Reader Service Card

Variable speed controls . . .

for dc motors from $\frac{1}{15}$ through 3 hp are available in 15 stock models. Operate from standard 50/60-c ac, single-phase, 115 v (or 230 v in 1 hp and larger models). Can be connected to any standard shunt or compound wound dc motor and provide infinitely variable speed control from zero to max motor rpm in either direction (reversing switch is included in each control). **Pacific Industrial Controls Inc, 1212 6th St, Berkeley 10, Calif.**

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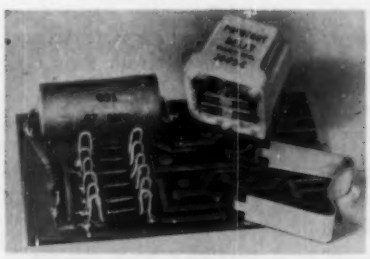

Printed contact relay . . .

includes new gold-plated spiral spring connectors placed on the coil terminals, which permit its use with single-sided printed circuit boards. Simplified blade design increases wiping action, extending life and current ratings. Completely plug-in unit is encapsulated in $\frac{3}{4}$-in. high-impact plastic cube and uses a permanent magnet instead of return spring to hold armature open. Magnetic force remains constant and eliminates maintenance adjustment. Mounts on and becomes integral part of printed circuit board, making possible substantial savings in space, weight and assembly costs. Fixed contacts are eliminated, and moving contacts, which are part of armature assembly, mate with copper conductors printed on circuit board, which are plated with rhodium over nickel. Various circuit board patterns available make it possible to use a single relay for up to 3PDT switching arrangements. Standard coil resistances are 75, 300 and 1200 ohm (500 mw) at 6, 12 and 24 v dc with pull-in occurring at 80% of rated voltage. Operates in excess of 1 million cycles with a contact load of 1 amp at 24 v dc or $\frac{1}{4}$ amp at 115 v ac. Life exceeds 5 million operations from dry circuitry up to $\frac{1}{4}$ amp, 24 v dc. **Executone Inc, Components Div, 47-37 Austell Pl, Long Island City 1, NY.**

Circle 311 on Reader Service Card

Waterproof connector . . .

has banana pin screw-in connection which allows it to be repaired in the field. Differs from other plugs which are vulcanized into end of wire, necessitating entire length of wire to be sent to factory for replacement when trouble is encountered. Unit detaches from end of wire, and two halves connect with banana pin, making it possible to repair it in less than 4 min. without molding. Available individually with custom-size rubber nipples to fit cable with which it is to be used. From stock at approx $5 each. **Vector Mfg, Engineering Dept, 5616 Lawndale, Houston, Tex.**

Circle 312 on Reader Service Card

Extra-wide galvanized sheet

is available up to 72 in. in width. Can be ordered as sheared sheet up to 20 ft long or in continuous coils up to 50,000 lb and in any gage thickness from 0.1196 to 0.0299 in. Base price is same as for galvanized steel sheet, and usual extras apply for special width. Delivery in 6 to 8 wk. **Armco Steel Co, Middletown, Ohio.**

Circle 313 on Reader Service Card

Lightweight porous ceramics . . .

of 96% alumina, fused silica or steatite are available on a limited basis. Alumina can be supplied with a density of as low as 1 gm per cc and a dielectric constant as low as 2, in blocks up to 10 x 6 x 2 in. Flex-

continued on page 50

ural strength is 1100 psi at density of 1 gm per cc. Porous steatite is made in blocks up to 12 x 6 x 2 in. or in 4-in. cubes at 0.7 gm per cc. Porous fused silica at densities down to 0.8 gm per cc is available over a wide size range to large blocks. Materials have interconnected pores ranging generally between 2 and 15 microns in dia. Other porous oxide ceramics have been experimentally produced. **Gladding, McBean & Co, R & D Div, 2901 Los Feliz Blvd, Los Angeles 39.**

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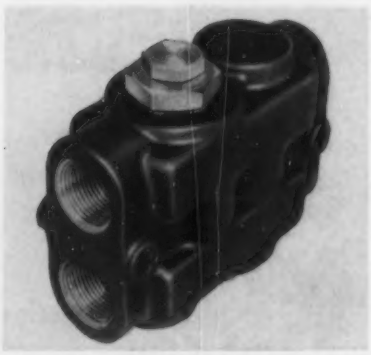


Cushion type pressure relief valve . . .

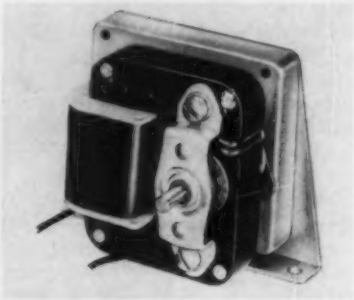
incorporating two independent cartridge relief valves, checks overloads in hydraulic systems. Developed originally to serve as a brake in swing circuit of backhoe, unit provides overload protection for any actuator subject to fast reversals of load. Also can be used to protect auxiliary systems. Two cartridge relief valves control flow through unit when high system pressures are encountered. Thus, momentary high pressure surges are relieved, since flow is diverted directly to low pressure side of actuator through either of the two pilot-operated valve. Use of independent valves also cuts in half number of times relief valve opens for each cycle, prolonging valve life. At full rate flow of 30 gpm, there is a differential of less than 100 psi from trickle to full flow and less than 50 psi between cracking and closing pressures. There is said to be no internal leakage. Pressure can be adjusted between 250 and 3000 psi. Two guided ball check valves with hardened steel seats prevent reverse flow through main valve. **Fawick Corp, Hydraulic-Electronic Div, 9919 Clinton Rd, Cleveland 11.**

Circle 315 on Reader Service Card

Direct-operating relief valve . .

for mounting on hydraulic pumps with standard SAE ¼-in. 4-bolt connectors, has a capacity of 3000 psi. Said to have fittings and space and to reduce labor, unit features an unusually low differential between opening and full flow. Pressure control is by simple adjustment of a single setscrew with locknut. **J E Myles Inc, 2406 Hilton Rd, Detroit 20.**

Circle 316 on Reader Service Card



Fhp gear motor . . .

has a magnetic clutch that disengages rotor pinion from remainder of gear train when motor is de-energized. Prevents coasting of output shaft and provides free-wheeling gear train so that output shaft can be turned manually when power is off. Special nylon helical rotor pinion and first gear results in extremely low noise level. Motor is 2P, shaded pole, ac induction unit available in voltages from 6 to 220 v, 50 or 60 c. Gear-reducer has output speeds from 1 to 800 rpm and output torque u, to 50 in.-lb at 1 rpm. Available output-shaft diameters: 5/16, ¼, 5/16 and ⅜ in. **Molon Motor & Coil Corp, 3737 Industrial Ave, Rolling Meadows, Ill.**

Circle 317 on Reader Service Card

Rear projection data readout

uses a special design lens system for display on almost the full viewing screen face. Said to provide up to 115% more message area than other readouts with same size screen. Lens system combined with a deeper than conventional case makes possible more than 1½ sq in. useable viewing area, compared with ¾ sq in. provided by other models. Multiple word messages, such as Start, Ready, Fire, can be communicated in full top-to-bottom viewing area. Available in assemblies or as individual units. Each unit measures 1 5/16 x 2⅜ x 6½ in. **Industrial Electronic Engineers Inc, 5528 Vineland Ave, North Hollywood, Calif.**

Circle 318 on Reader Service Card

Strain-gage pressure transducer . . .

uses silicon semiconductor sensing elements to provide extra high accuracy throughout its entire operating temperature range of —65 to 250 F. Measuring 2¼ x 1½ x 2¾ in. with tapped hole mounting feet, the high-line, low-differential unit has pressure ranges from 0-10 to 0-10,000 psid, or ±10 to ±10,000 psid. Standard electrical outputs are 50 mv, 250 mv and 5 v dc (suitable for transmitting output signal over a long line). Standard internal temperature compensation is from 0 to 150 F (compensation over entire operating temperature range on request). Has self-contained calibration, and, with replacement of metallic strain-gage materials by piezo-resistive semiconductor materials, number of mechanically functioning parts has been reduced to two. Combined linearity and hysteresis is ±0.25%; output at zero applied pressure, ±3%. Line pressure zero shift is ±0.1%/1000 psi. Internal calibration equals ½ full range pressure sensitivity within 0.5% 0 to 150 F. Output load, open circuit, is 2000 ohm; max excitation without damage, 1.5 times rated voltage, limited by 40 v dc. Unit operates in all gaseous and liquid media for measuring, testing and control of pressures. **Fairchild Controls Corp, 219 Park Ave, Hicksville, LI, NY.**

Circle 319 on Reader Service Card

Resistance-temperature transducer . . .

using a platinum element, provides continuous operation at temperatures as high as 2000 F. Recommended for installation by high-temperature cement on a surface where temperature is to be measured. Installation by welding also is possible. Unit is 1 5/16 x 5/16 x 0.014 in. thick. It can be installed with response times in millisec. Platinum element resistance is 100 ohm ±1% at 77 F. Temperature range is 0 to 2000 F. Cement kit, furnished with each transducer, permits bonding the device to ferrous and non-ferrous metals and alloys. **Winsco Instruments & Controls Co, 11789 W Pico Blvd, Los Angeles 64.**

Circle 320 on Reader Service Card

Continuous duty induction motor . . .

is a 1-hp, totally enclosed, fancooled unit that operates at a speed of 5500 rpm. Other specifications include: power, 208 v, 400 cps, 3 phase; full load torque, 15.3 oz-ft; starting torque, 160% (full load torque); pull-out torque, 300% (full load torque); full load current, 4 amp; starting current, 15.8 amp; efficiency, 79.5%; and weight, 17 lb, 15 oz. **Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.**

Circle 321 on Reader Service Card

Internal thread spacers . . .

are available in brass and corrosion resistant steel and in lengths from ⅛ through 1½ in. in 1/16-in. increments. Thread sizes

continued on page 53

RBW FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of gasketed joints

The right fastener for a "flexible" joint rests on type of gasket material and its compressibility. Total preload on all the fasteners in the connection must be enough only to compress the gasket and provide sufficient additional clamping force to withstand the hydrostatic test pressure. More than this brings on a good chance of leakage, through "bowing" of the clamping plate.

Exaggerated sketch showing how too much torque tends to distort clamping plate and leads to leakage.

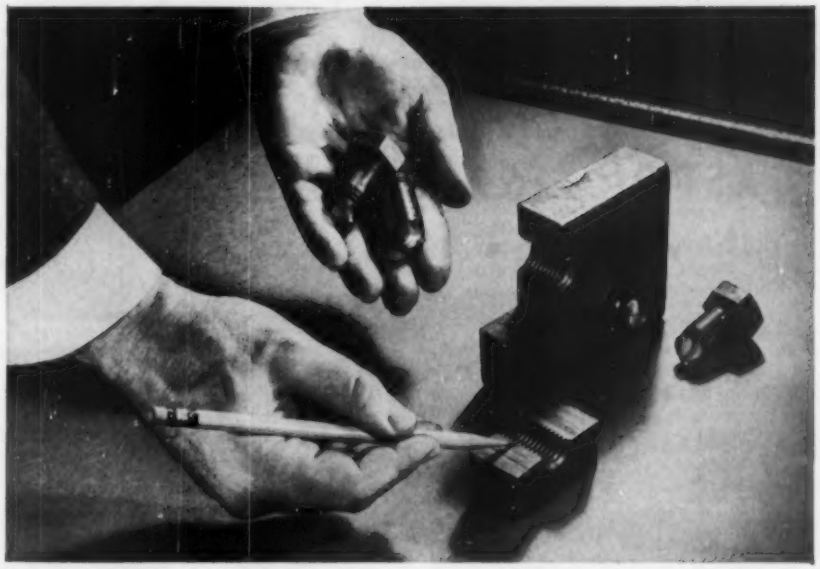
HYPOTHETICAL CASE

Suppose a joint is tightened with Grade 5 Hex Screws to their yield strength, and leakage develops. By going to alloy screws and tightening still further you would still get leakage. But Grade 2 Hex Screws, all torqued evenly, would no doubt solve it.

ACTUAL CASE

The fasteners on one product's flange had to withstand a 4000 pound hydrostatic pressure. But the hard asbestos gasket used took a bolt load of 28,000 pounds for sufficient compression to seal. By substituting a rubber and fibre gasket in this case, bolt load could be reduced. So could bolt size, thereby saving 73% on fasteners.

Using Hex Screws in tapped holes saves money



In the cast "coupon" shown above, the hex screws were torqued tight and removed 50 times—then torqued to failure. Note in the cutaway that the casting's threads are still perfect with no sign of stripping. It was the screws which broke—a clear demonstration that castings fastened with hex screws will suffer no thread damage during repeated disassemblies.

TWOFOLD BENEFIT

When there are no space clearance problems or other special requirements, using studs of 1-inch diameter or smaller often penalizes the user. First, in direct costs, since the more economical hex head screws will do the job to specification. And second, in production costs, since studs require that tapped holes have an *interference* thread fit, which in turn results in slow, "selective" assembly to determine properly mated threads. Hex screws need only a *clearance* fit, assemble faster.

ACTUAL EXAMPLE

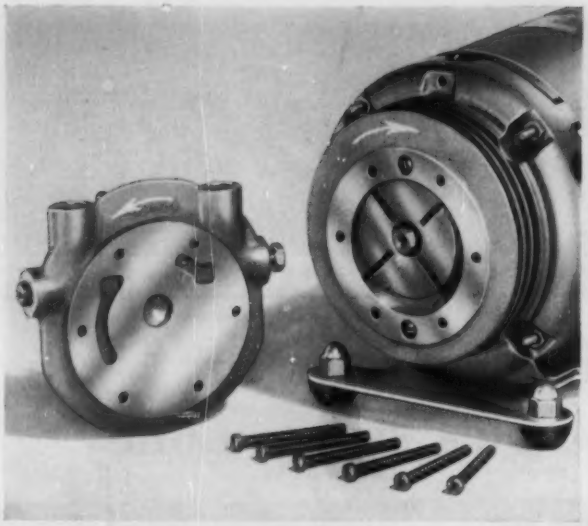
In one of his surveys of fastenings used by one company, the RB&W engineer pointed out that over 250 stud fastenings were being used in a large refrigeration unit. The same number of hex screws, costing $8.45, saved $22 over the studs and nuts. Annually, the total would be $7,800 on the production run of this unit.

Not to be overlooked either was the tangible saving on the less critical tapping job required.

RB&W offers its help on your specific fastener problems, or an overall survey of your fastener usage. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

CIRCLE 51 ON READER SERVICE CARD



NEED AN OIL-FREE AIR SUPPLY?

Select from 3 types, 10 sizes

GAST OIL-LESS* AIR PUMPS

You gain five advantages when you specify Gast Oil-less Air Compressors or Vacuum Pumps.

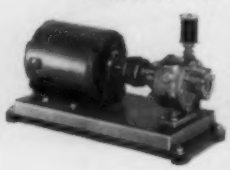
1. Absolutely oil-free air delivery. No hot oil mist or odor can contaminate air flow.
2. No lubrication required. This eliminates problems for both manufacturer and user.
3. Lubrication costs for both time and lubricants are eliminated.
4. You have greater freedom in locating the pump, as easy access for oiling isn't a factor.
5. Oil-less design adds a sales feature to your product!

How is this possible? Rotary design has carbon vanes that lubricate themselves. Ball bearings are grease-sealed for life and located outside the pumping chamber. Simple construction assures long, trouble-free dependability.

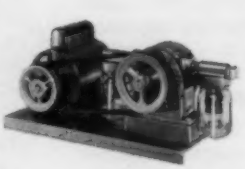
Ten sizes; capacities from .35 up to 24 c.f.m. running open. For medium duty to 10 p.s.i.g. pressure or 20" Hg vacuum. For use on instruments, medical and laboratory equipment, food packaging and paper-handling machines, Gast Oil-less Air Pumps have much to offer.

Miniature models, .35 to 1 c.f.m.

Direct coupling drive, to 5.9 c.f.m.



Integral-motor types to 1.1 c.f.m.



V-belt drives, up to 24 c.f.m.

A wide range of lubricated models also available.

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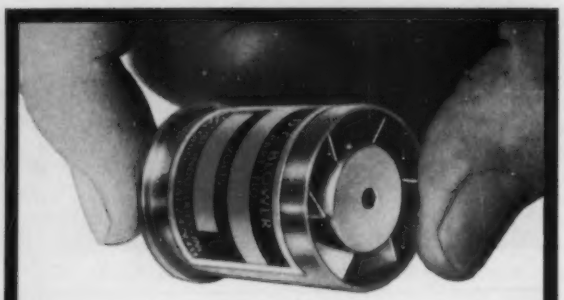
Air Motors • Vacuum Pumps • Compressors

GAST MANUFACTURING CORP.
P. O. BOX 117-V, BENTON HARBOR, MICHIGAN



NEW SMALLEST VANEAXIAL BLOWER

Only 1.1" in diameter by a maximum 2.4" long, this smallest d.c. blower moves 10 cfm of air against 0.3" H_2O back pressure! Use this rugged sub-miniature blower for spot cooling of critical components where space is cramped and weight is important.

VAX-1-DC blower operates on 28 v.d.c. or less, using a maximum of 200 milliamps. Weight is 1.4 ounces. Mounts with standard servo ring clamps. (Globe makes larger blowers also.) Request Bulletin VAX-1 from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

CIRCLE 63 ON READER SERVICE CARD

PARAMOUNT Die Castings AT WORK
No. 5 of a Series

Pump Housing

Gear Case Cover

RCA-Whirlpool Imperial Mark XII Automatic Washer

PARAMOUNT— a major supplier of die castings to Whirlpool Corporation for 15 years

Whirlpool quality is recognized throughout the world, quality which stems from the rigid quality standards which Whirlpool demands that its suppliers meet.

Paramount's engineering and production "know-how", its ability to consistently meet Whirlpool's exacting quality standards—as in these die castings for the RCA-Whirlpool Imperial Mark XII Automatic Washer—are the reasons why Paramount has consistently been one of Whirlpool's major suppliers for 15 years.

It Will Pay You To Look to Paramount . . .
If your product incorporates die castings or you're considering them—investigate Paramount's complete services.
Three complete plants—two in St. Joseph, Mich., one in Seymour, Indiana.

SEND For "Designing for Die Casting"

PARAMOUNT Die Casting Co.
(A subsidiary of TALON, INC.) ST. JOSEPH 4, MICHIGAN

CIRCLE 64 ON READER SERVICE CARD

range from #2 through ⅜, coarse and fine series, class 2B fit. Shapes include round, diamond knurl and hexagon with threads through entire length of insert. Used for feed-through mounting of coils and magnetic components in cast resins, injection and compression molded parts (knurled type) and stand-off mounting of sheet metal parts (round and hexigon types). From stock. **Standard Insert Co, 1710 Potrero St, South El Monte, Calif.**
821-21

Circle 322 on Reader Service Card

Pneumatic control switch . . .

produces an electric signal when an object interrupts flow of air across an opening (signal can be used for automatic control of production equipment). Detects presence or non-presence of any solid object without physical contact, regardless of the material. Unit is a 7-amp, 120-v, SPDT, snap-action switch, operated by directing approx 1.5 psi jet of air against its diaphragm. Installed with an air line leading from a flow control valve to an open end. A receiver tube to the switch is installed opposite the line leading from the control valve. Light pressure directed against the diaphragm actuates the switch. An interruption in this pressure changes the diaphragm's position, thereby reversing the contacts. **Automation Devices Inc, 3125 Brandes St, Erie, Penna.**

Circle 323 on Reader Service Card

Vinyl handle . . .

has either Mylar-protected gold-or silver-colored insert laminated to it or a simulated leather texture. Steel or brass hardware in any of 12 finishes fastens by means of prongs which are bent on undersurface of mounting area. Available in any length. Leather version is produced in 13 colors. One test assembly reportedly lifted a 24-lb load 56,000 times without developing signs of wear. **Philadelphia Handle Co, 1643 Haddon Ave, Camden 3, NJ.**

Circle 324 on Reader Service Card

Shock test machine . . .

based on principle of free fall with elastic impact, is said to be substantially less expensive and simpler to operate than pneumatically driven shock tester. Equipment to be tested is bolted onto very rigid table, which then is lifted to proper drop height. Table is released and allowed to fall until programmed shock absorber beneath it impacts on machine base plate. Shock absorber absorbs kinetic energy of falling package; then returns this energy to accelerate package upward. When table reaches top of this rebound, it is arrested automatically by braking system. A single pulse shock input is thus provided by the shock absorber, while acceleration before and after shock pulse is limited to approx acceleration of gravity. Available with any one or a number of shock programming cylinders, depending on number of shock waveforms required. Equipment weighing several hundred pounds can be tested on machine. Only limitations on test specimen are table max design load of 50,000 g-lb and space envelope of 36 x 28 in. Relative impulse (average acceleration x duration) of shock inputs can be varied from 0 to 1750 g-millisec. This exceeds MIL-E-5272A requirements in that half-sine shock inputs of 11 millisec duration and 300-g peak acceleration can be obtained. **Monterey Research Laboratory Inc, PO Box 1309, Monterey, Calif.**

Circle 325 on Reader Service Card

Tracing paper . . .

is 100% rag stock, said to produce "outstanding" blueprint and diazo reproduction copies. Has fine-toothed surface, giving it top pencil-taking and inking qualities for layout, sketch, drawing and tracing, coupled with a high erasability. Available in standard roll lengths and widths, as well as wide variety of sheet stock sizes used in engineering/drafting field. **Charles Bruning Co Inc, 1800 W Central Rd, Mt Prospect, Ill.**

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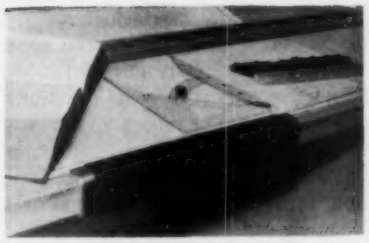

Pants guard . . .

is sponge rubber-covered aluminum channel that slides on guard rail of drawing board. Keeps pants from becoming frayed by constant rubbing against guard rail. As draftsman leans against channel, it slides along with his movements from side to side. Priced at $2.50 each. **Best Yet Products, 10719 S Rhodes, Chicago 28.**

Circle 327 on Reader Service Card

Breadboarding kit . . .

enables prototypes to be completed using no more tools than a soldering iron. Comprises an assortment of pre-punched laminated-phenolic panels, terminal strips, volume control strips, silver-plated snap-in turret terminals, punched chassis frames, end plates, rack mounting plates and assorted hardware. Panels have holes for both miniature and octal tube sockets, for potentiometer shaft bushings and for the snap-in terminals. These double-turret, slotted terminals are pushed into the panels, and once inserted, held securely without turning. If necessary, they can be removed for re-use or re-location. Extend far enough through panel so that wiring connections can be made on both sides of panel. Chassis frames are 16⅞ in. long and, with mounting plates, fit standard 19-in. racks. Angle brackets and stand-offs allow panels to be grouped in practically any desired relation to each other. Complete kit is priced at $13.95. **Precision Metal Products Co, 41 Elm St, Stoneham, Mass.**

Circle 328 on Reader Service Card

Metal calendar board . . .

is a permanent wall and easel unit for visibly scheduling work and activities. User writes directly on face of board in 4¾ x 4-in. dated spaces with black and colored "china" marking pencils. Erases at will with cloth or paper towel. Magnetic date pieces, numbered 1-31, are changed as dates or months expire. Includes chart which provides 15-yr guide for correct monthly calendar starting dates and ¾-in. wide tray at bottom for holding pencils, cards, etc. Board is 34 x 23 in. and weighs 6 lb. Complete assembly is priced at $19.75. **L D Blehart Co, 10 Fiske Pl, Mt Vernon, NY.**

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RULON® AND TEFLON®

RULON — first practical fluorocarbon for cup packings

Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.

Dixon offers **RULON** and **TEFLON** in

- rods
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RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, 103 BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

DESIGN LITERATURE

Engineering Data for Product Design

DOUGLAS C GREENWOOD, associate editor. McGraw-Hill Publishing Co, Inc, 330 W 42 St, New York 36. 8½ x 11, 430 pp. $10.

Articles in this volume are drawn from Product Engineering and have been edited and classified to facilitate easy reference. The material covers such subjects as metals and alloys, nonmetallic materials and finishes, design analysis, beams, torque, moment of inertia, bearings and shafts, springs and vibration, and mechanical control. The book also includes fastening and joining methods, and covers electricity, electronics, hydraulics, and pneumatics, all from the standpoint of the design engineer.

A Guide to Technical Literature Production

EMERSON CLARKE. T W Publishers, River Forest, Ill. 6 x 9, 192 pp. $3.

Written for those who must create, buy, or otherwise produce technical literature. Technical literature in this case refers to service manuals, maintenance manuals, parts catalogs, military handbooks, and engineering reports of all types. For engineering staffs without technical writing facilities, the book outlines the problems involved in organizing a writing group, or of obtaining technical writing services.

Transistor Logic Circuits

RICHARD B HURLEY. John Wiley & Sons, Inc, 440 Park Ave S, New York 16, 5¾ x 9, 363 pp. $10.

Book covers both logical mathematics (with logical routines and blocks) and the transistor circuits that implement the mathematics and blocks. There are several dozen pages on elementary binary arithmetic and Boolean algebra. This is followed by a basic treatment of diodes and transistors and a section combining the mathematics with the devices in logic circuits. A variety of application examples are given.

Filters and Attenuators

ALEXANDER SCHURE. John F Rider Publisher, Inc, 116 W 14th Street, New York. 5½ x 8½, 96 pp. $2.25.

This simplified book makes electronic filters and attenuators readily understandable to a mechanical engineer. Both narrative and mathematical presentations are used. The capacitor-input type filter in power supplies is analyzed together with power supply problems and solutions. Also covered are audio and video filters, wave filters, and specialized filter types.

Other Books of Interest

Design Information on Ph 15-7 Mo Stainless Steel for Aircraft and Missiles

PB 151093, Favor, Deel, Achbach. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, 38 pp. $1.25.

18 Questions and Answers About Radiation

US Atomic Energy Commission. Available from Superintendent of Documents, US Govt Printing Office, Washington 25, DC. 6 x 9¼, 47 pp. 25¢.

Management Guide to Human Relations in Industry

B T Lewis, W W Pearson. John F Rider Publisher Inc, 116 W 14th St, NY 11. 5½ x 8½, 64 pp. $1.25.

Tunnel Diode Manual

General Electric Co, Kelley Building, Liverpool, NY. 5½ x 8½, 96 pp. $1.

ABSTRACTS FROM THE LITERATURE

Valves

Discusses factors involved in selection, recent advances in materials and fluid loss technology, a study of fluid-end types, available valve actuators, and some practical maintenance suggestions.

"Valves," T. W. Edwards, Associate Editor, Power, June '61, 330 W. 42 Street, NYC.

Distortion and Residual Surface Stress in Grinding and Milling

Reports on a study conducted under a USAF contract to determine factors responsible for distortion in high-strength steels during surface grinding and milling.

"Distortion and Residual Surface Stress in Grinding and Milling of High Strength Steels," Nowikowski, Maranchik, and Field, Metcut Research Assoc, Inc. SAE paper 340L, Society of Automotive Engineers, Inc, 485 Lexington Avenue, NYC.

Strain Gages in Three-dimensional Stress Analysis

Gives method for constructing resistance-wire strain gages which may be embedded in a plastic model. Also described are methods for calibrating gages and the photoelastic tests to investigate the effect of the gages on the stress pattern. Application of this

new three-dimensional technique to evaluate the stress distribution in a thick-walled cylindrical pressure vessel is discussed. Correlation between experimental data and calculated values is given.

"Use of Electrical-resistance Strain Elements in Three-dimensional Stress Analysis," R. I. Brasier, Los Alamos Scientific Lab; R. C. Dove, Univ of New Mexico. Experimental Mechanics, June '61, 20th and Northhampton Streets, Easton, Pa.

Control Valves

Pumping a fluid through a valve costs money. Present methods of valve sizing do not take this into account. Hence the author argues that control valve sizing should be based on smallest annual operating cost, not smallest first cost, provided of course that the selected valve gives good control. A numerical example comparing the economic and conventional methods of valve sizing is given.

"Control Valves—first cost vs operating cost," William J. Schmidt, Stone & Webster Engineering Corp. Control Engineering, May '60, 330 W. 42 Street, NYC.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 57.

ELECTROMECHANICAL PARTS—Catalog 65, 552 pp. Sepcifications, prices and test reports useful in design and prototype work are presented for 67 product categories, including speed reducers, magnetic clutches and brakes, differentials, electronic hardware, Teflon terminals and limit stops. Sterling Instrument, Div of Designatronics, 5 Sintsink Dr, Port Washington, NY.

Circle 350 on Reader Service Card

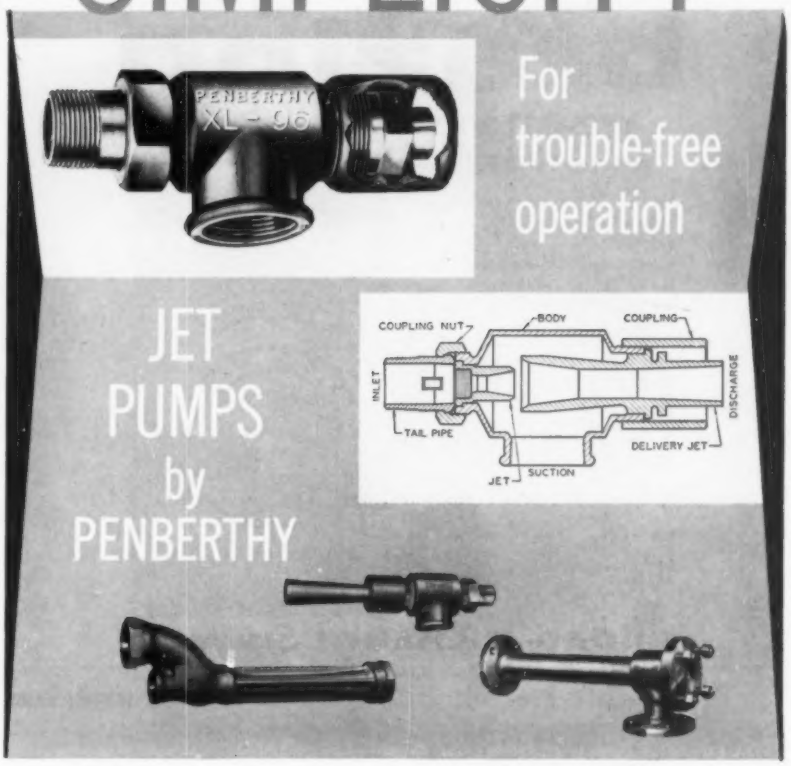
SILICONE FLUIDS—Booklet S-9, 20 pp. Differentiates between available grades according to viscosity and classifies them on the basis of physical properties. Carried are a physical data summary chart and a silicone fluid selector, in which available grades are identified by major application areas. Performance curves are included. Silicone Products Dept, General Electric Co, Waterford, NY.

Circle 351 on Reader Service Card

PATTERNED ALUMINUM SHEET—Booklet, approx 28 pp. Supplies widths and lengths of alloys and tempers in which each of 41 different patterns is available (patterns are reproduced full scale on textured heavy stock). Also discusses flexibility of patterened sheet as a design

continued on page 56

SIMPLICITY



If you have a liquid heating, circulating, aerating, agitating, pumping or blending application (to mention a few), you'll find, chances are, that there just isn't a more economical, efficient, trouble-free device for handling the job than a Penberthy Jet Pump. They cost little to buy, little to install. And maintenance? Practically non-existent, for there are no moving parts, no packing glands, nothing to lubricate.

Penberthy, what's more, as the #1 name in Jet Pumps . . . with almost 70 years' experience in the field . . . offers you the broadest available selection of models, standard or special, steam, air or liquid operated, in a variety of materials. Ask a Penberthy engineer for assistance with your jet pump application.

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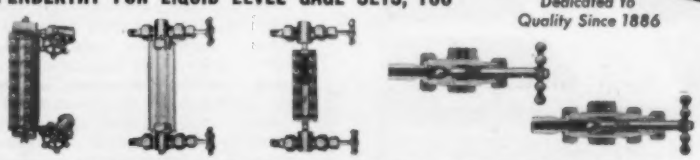

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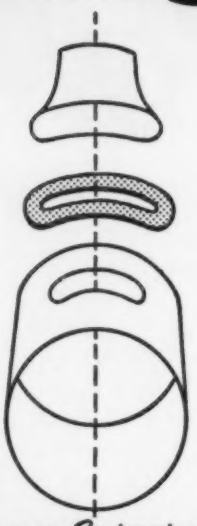
CIRCLE 55 ON READER SERVICE CARD

NEW CURVED
brazing
washers
and shims

The operator no longer needs three hands to put the components together!

Applications on which one tube is radiused or saddled to fit over another are sometimes difficult to preform with a washer or shim. The stiffness of the washer may hold the radiused member away from the other tubes. By curving the washer to the curvature of the tube, the problem is minimized. Curving a shim permits snapping of the shim onto the tube.



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CIRCLE 65 ON READER SERVICE CARD

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ANNUNCIATORS

Step or momentary action switches and annunciators featuring:

Simple, functional design • Mounting independent of panel thickness • Front of panel lamp replacement • Highest quality construction • Screens in six colors 0.25A - 220 V.D.C. current capacity • 5A - 220 V.A.C. current capacity • Extreme long life

Prices in unit quantities from $5.00 to $9.00

Precision rotary switches, snap action switches and annunciators

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Wanted For Small Mfr.—Must have E.E. or M.E. degree to design and supervise manufacture of resistors for railroad dynamic brake eqpt., mech. or diode type voltage regulator, industrial crane & power control board resistance units for low or high voltage starting eqpt. AC or DC. Salary open to negotiation. Reply to Suite 1414 (P), 4 Gateway Center, Pittsburgh 22, Pa.

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DESIGN LITERATURE

medium. Aluminum Co of America, 724 Alcoa Bldg, Pittsburgh 19.

Circle 352 on Reader Service Card

EPOXY PRODUCTS—Catalog 1961, 48 pp. Reviews technical data, including physical, chemical and electrical properties, of bonding agents, potting compounds, sealants, coatings and accessories. Methods of application are spelled out. Carl H Biggs Co Inc, 1547 14th St, Santa Monica, Calif.

Circle 353 on Reader Service Card

VIBRATING EQUIMENT—Pocket size catalog 616, 72 pp. Describes, illustrates and offers specifications of vibratory materials handling equipment, vibrating parts handling equipment, mechanical shaft seals, paper joggers, portable power tools and power rectification equipment. Syntron Co, 240 Lexington Ave, Homer City, Penna.

Circle 354 on Reader Service Card

FRACTIONAL-HP GEARMOTORS — Bulletin 1300, G, H, 2 pp. Provides specifications and dimension drawings of in-line and right-angle designs. Also lists gearbox specifications. Ohio Electric Mfg Co, 5400 Dunham Rd, Maple Heights, Ohio.

Circle 355 on Reader Service Card

LOW PRESSURE CELL—Bulletin R-4, 2 pp. Traces design features, output voltages ,special applications, ranges and max static or line pressure of the pressure measuring device. Outline drawings and a curve showing an actual calibration example are included. Control Components Div, International Resistance Co, 401 N Broad St, Philadelphia 8.

Circle 356 on Reader Service Card

STRUCTURAL SHEET METAL—Manual, 59 pp. Reviews variety of available materials; applications, with illustrations; all parts and components needed; methods of assembly, with illustrations; special applications such as inside corners, panel-inside construction, insulating, etc; and test data in graph and tabular forms. International Steel Co, Lindsay Structure Div, 1321 Edgar St, Evansville 7, Ind.

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HIGH VACUUM VAPOR PUMPS — Bulletin 6-1, 54 pp. Covers oil and mercury pumps in both metal and glass, providing performance details and curves, condensed specifications, and formulas for selecting proper pump. Consolidated Vacuum Corp, 1775 Mt Read Blvd, Rochester 3, NY.

Circle 358 on Reader Service Card

REGULATED POWER SUPPLIES — Long form catalog 1961, 44 pp. Outlines developments in regulated transistor-

equipped power supplies and lists complete specifications. Typical output impedance and recovery curves are included. Harrison Laboratories Inc, 45 Industrial Rd, Berkeley Heights, NJ.

Circle 359 on Reader Service Card

BOLT WITH BUILT-IN STRAIN GAGE—Bulletin 361-2, Mechanical and electrical specifications are given for the strain measuring device available in two configurations. Prices are included. Strainsert Co, 24 Summit Grove Ave, Bryn Mawr, Penna.

Circle 360 on Reader Service Card

MATERIALS DEVELOPMENT—Periodic newsletter, 2 pp. Discussion of sintered titanium parts launches external publication. Subsequent issues will cover: scientific materials selection, advanced metal applications, fiber metallurgy and tungsten composites. Editor, Materials Scope, Mechanical Research Div, Clevite Corp, Cleveland 8.

Circle 361 on Reader Service Card

REPRODUCTION PROCESSES, MATERIALS — Periodic newsletter, 6 pp. First issue covers techniques of drafting on reproduction film as opposed to drafting film. Upcoming issues will deal with other "how-to" phases of industrial reproduction. The Kodak Compass, Sales Service Div, Eastman Kodak Co, Rochester 4, NY.

Circle 362 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

HOSE AND HOSE COUPLINGS—Catalog, 12 pp. Describes, illustrates and supplies specifications and dimensions of industrial and automotive hose, hose couplings, union adapters and connectors. Outline drawings and cutaways are included. American Coupling Corp, 31739 Mound Rd, Warren, Mich.

LOCK WASHERS—Bulletin, 4 pp. Explains how helical spring lock washers work and how they maintain bolt tension to overcome basic causes of looseness in bolted assemblies. Mellowes Co, 125-P E Nash St, Milwaukee 12 .

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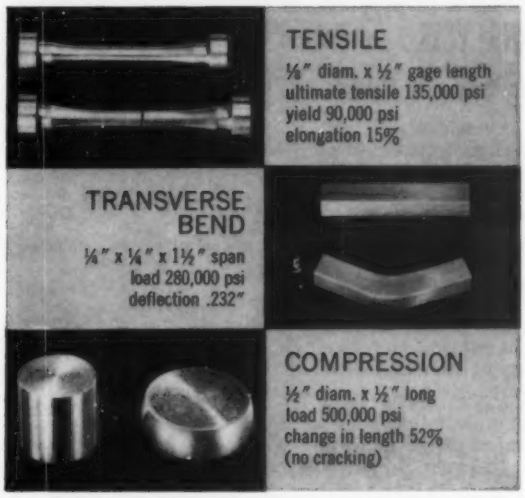

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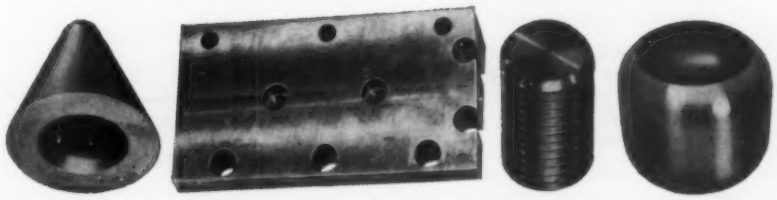

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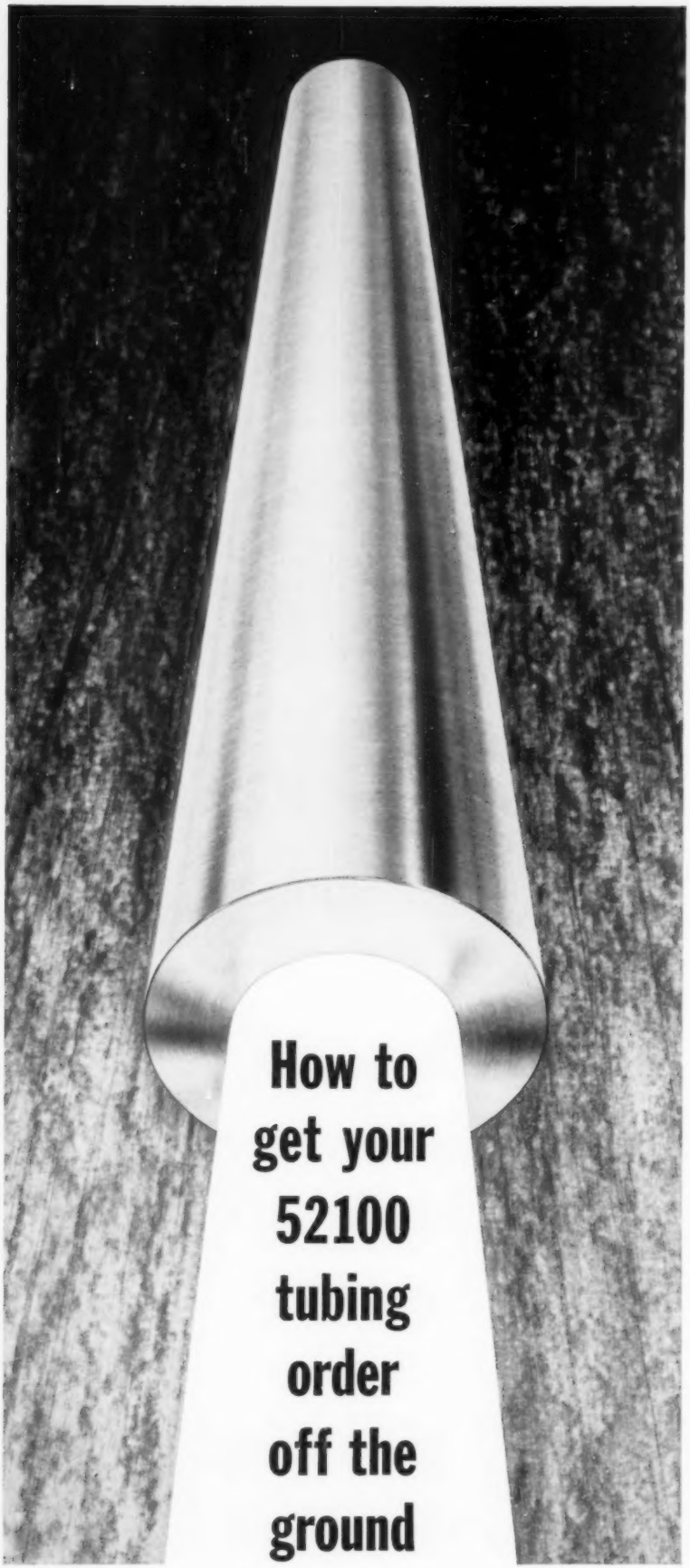

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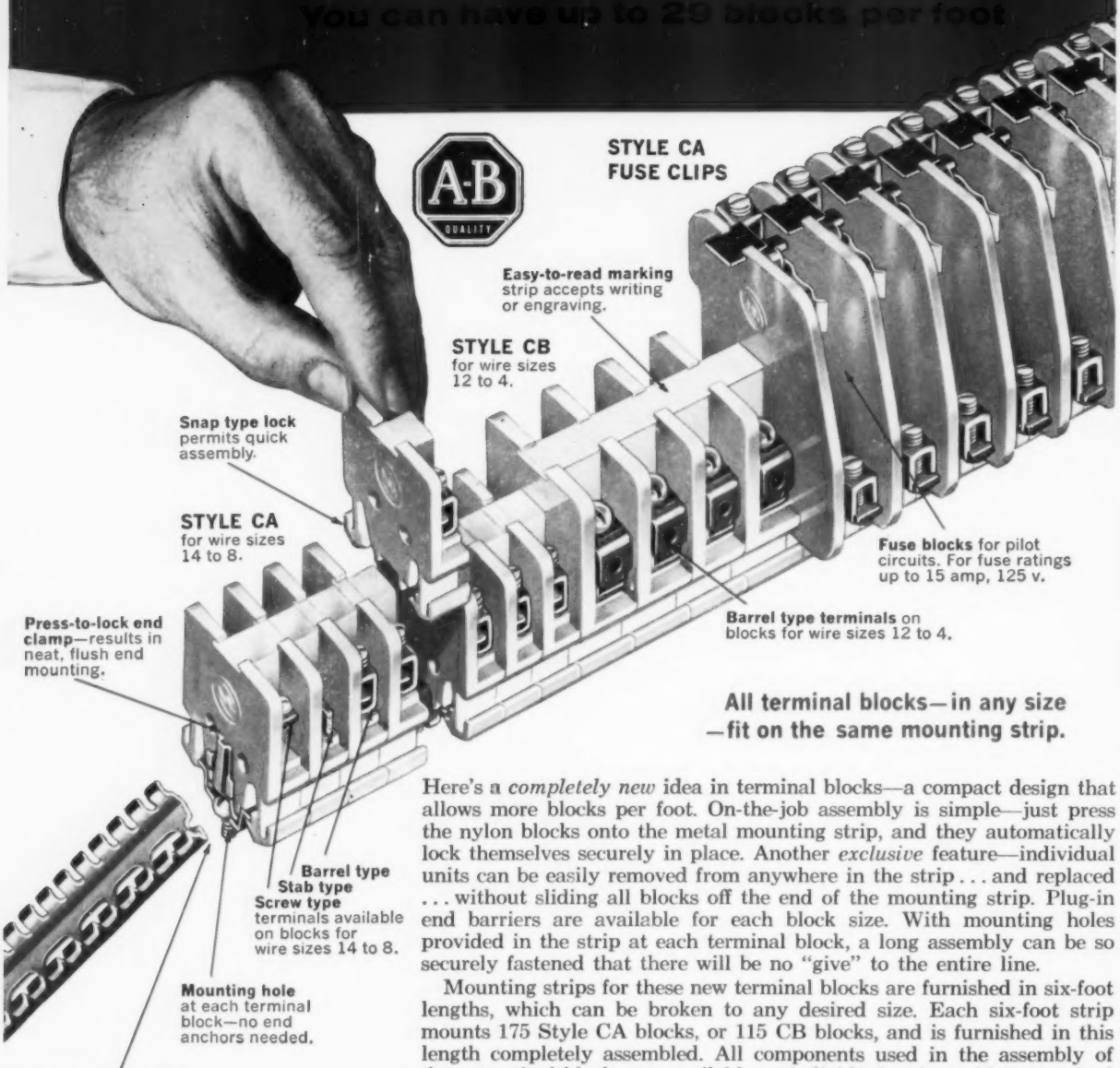
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